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EE/CA and RI/FS Support Sampling Plan

Sauget Area 1

Sauget and Cahokia, Illinois

Volume 2 - Appendix A

Soil, Groundwater, Surface Water, Sediment and Air FSP, QAPP and HASP

June 25, 1999

Submitted To:

U.S. Environmental Protection Agency
Chicago, Illinois

Submitted By:

Solutia Inc.
St. Louis, Missouri

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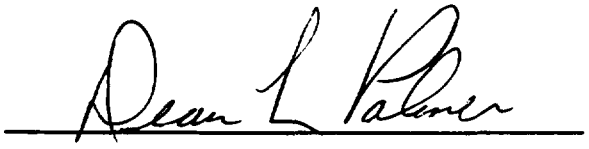
Soil, Ground Water, Surface Water, Sediment, and Air Sampling
FIELD SAMPLING PLAN

Sauget Area 1 Support Sampling Plan
Sauget and Cahokia, Illinois
Volume 2A

Remediation Technology Group
Solutia Inc.
St. Louis, Missouri



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June 1999

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1. Project background

This Field Sampling Plan (FSP) has been prepared by O'Brien & Gere Engineers, Inc. (O'Brien & Gere) on behalf of Solutia Inc. (Solutia) as part of the Support Sampling Plan at the Sauget Area 1 Site (the site) located along Dead Creek in the villages of Sauget and Cahokia, Illinois. This FSP details the activities to implement the Support Sampling Plan for field sampling, sample handling and storage, chain of custody, and field analysis efforts associated with sampling of environmental media at the Sauget Area 1 Site and is one component of the Engineering Evaluation/Cost Assessment (EE/CA) and Remedial Investigation/Feasibility Study (RI/FS) Support Sampling Plan (SSP).

The purpose of this SSP is to gather sufficient information from the Sauget Area 1 Site to identify the nature of waste materials in Sites G, H, I, L, M, and N and to assess the extent of constituent migration in soil, ground water, surface water, sediments, and air at the site. Figure 1 is a plan of the site.

The site description is presented in Section III of the Administrative Order by Consent (AOC) (USEPA, 1999) and in the Ecology and Environment, Inc. data report (Ecology and Environment Data Report) (Ecology and Environment, Inc., 1998). The source areas are designated as Sites G, H, I, L, M, and N, and Dead Creek Segments (CS) CS-A, CS-B, CS-C, CS-D, CS-E, and CS-F in the AOC and Data Report.

The activities described in this FSP will be performed in accordance with O'Brien & Gere's Health & Safety Plan (HASP) dated April 1999 and O'Brien & Gere's Quality Assurance Project Plan (QAPP) dated April 1999.

1.1. Site history, summary of existing site data, and problem definition

1.1.1. Site background

Sauget Area 1 is located in the villages of Sauget and Cahokia, St. Clair County, Illinois. The study area is centered on Dead Creek, an intermittent stream that is approximately 17,000 feet long, and its floodplain. The study area includes three closed municipal/industrial landfills (Sites G, H, and I), one backfilled wastewater impoundment (Site L), one flooded borrow pit (Site M), and one backfilled borrow pit (Site N). The study area also includes six creek segments:

Creek Segment A	Alton & Southern Railroad to Queeny Avenue
Creek Segment B	Queeny Avenue to Judith Lane
Creek Segment C	Judith Lane to Cahokia Street
Creek Segment D	Cahokia Street to Jerome Lane
Creek Segment E	Jerome Lane to Route 157
Creek Segment F	Route 157 to Old Prairie du Pont Creek

These sites and creek segments are shown on Figure 1.

1.1.2. Land use

During recent years, land use has been consisent in the area surrounding Dead Creek. In a 1988 report prepared for the Illinois Environmental Protection Agency (IEPA) (Expanded Site Investigation, Dead Creek Project Sites at Cahokia/Sauget, Illinois), Ecology and Environment indicated that "A wide variety of land utilization is present [in the study area]. The primary land use in the town [village] of Sauget is industrial, with over 50% of the land used for this purpose. Small residential, commercial, and agricultural properties are also interspersed throughout the town [village]. Significant land use features, in relation to individual project sites will be discussed below.

Land surrounding the Area 1 project sites is used for several purposes. A small residential area is located immediately east of Sites H and I, across Falling Springs Road. The nearest residence is approximately 200 feet from these sites. The Sauget Village Hall is also located on top of, or adjacent to,

Site I .... South of Sites G and L are two small cultivated fields which are used for soybean production. These fields separate the sites from a residential area in the northern portion of Cahokia. Several small commercial properties are also found in the immediate vicinity of the Area 1 sites." These land use patterns are typical of Dead Creek east of its intersection with Route 3 (Mississippi Avenue). Immediately south of Route 3 there is a residential area. After this developed area, Dead Creek runs through undeveloped area until it reaches the lift station at Old Prairie du Pont Creek.

1.1.3. Climate

Geraghty and Miller, in a report prepared for Monsanto (Site Investigation for Dead Creek Segment B and Sites L and M, Sauget-Cahokia, Illinois, 1992), indicates that "The climate of the site(s) is continental with hot, humid summers and mild winters. Periods of extreme cold are short. The average annual rainfall in the area for the period from 1903 to 1983 was 35.4 inches; however, precipitation increased to 39.5 inches per year during the period between 1963 and 1988. The average annual temperature is 56°F; the highest average monthly temperature (79 °F) occurs in July and the lowest average monthly temperature (32 °F) occurs in January."

1.1.4. Hydrology

According to Ecology and Environment (1988), "the project area lies in the floodplain, or valley bottom, of the Mississippi River in an area known as the American Bottoms. For the most part, the topography consists of nearly flat bottom land, although many irregularities exist locally across the site areas.... Generally, the land surface in undisturbed areas slopes from north to south, and from the east toward the river. This trend is not followed in the immediately vicinity of [Sauget Area 1]. Elevations of Area 1 sites range from 410 to 400 ft above mean sea level (MSL) ... Little topographic relief is exhibited across individual sites, with the exception of Site G ...

Surface drainage in the project area is typically toward ... Dead Creek. However, significant site-specific drainage patterns are present. A brief description of surface drainage for individual sites is given below.

Site G - Drainage at Site G is generally east toward CS-B. A large depression exists in the south-central portion of the site. Surface runoff flows toward the depression [Note: As a result of an emergency response action by USEPA

Region V in 1995, Site G is capped and surface water flow is directed radially away from the site].

Site H - Drainage at Site H is typically to the west toward CS-B. Several small depressions capable of retaining rainwater, are scattered across the site. Precipitation is these areas infiltrates the ground surface rather than draining from the site.

Site I - Drainage is generally to the west toward the two holding ponds which make up CS-A. [Note: Creek Segment A was closed under an IEPA-approved plan in 1990/91. Impacted sediments were removed and transported off-site for disposal, a high-density polyethylene (HDPE) membrane vapor barrier was installed, a storm water retention basin was constructed, and the site was backfilled to create a controlled-access truck parking lot. Water that used to be impounded in CS-A is now drained to the new storm water retention basin.] CS-A also receives surface and roof drainage from the entire Cerro plant area located west of CS-A. This drainage flows through a series of storm sewers and effluent pipes. A large depression exists in the northern portion of Site I [Note: This depression no longer exists]. Precipitation in this area flows toward the depression.

Site L - Site L is a former subsurface impoundment which has subsequently been covered with highly permeable material (cinders). Runoff from the surface, although inhibited by the permeable nature of the cinders, flows toward CS-B.

Site M - Site M receives surface runoff from a small residential area located east and south of the site. Water in Site M eventually drains into CS-B through a cut-through located in the southwest corner of the site.

Site N - Because the excavation which constitutes Site N [is] only partially filled, it receives runoff from the surrounding area. The creek bank in this area (CS-B) [CS-C] is approximately ten feet higher that the lowest point in the excavation.

Dead Creek - Dead Creek serves as a surface water conduit for much of the Sauget and Cahokia area. The creek runs south and southwest through these towns [villages] to an outlet point in the [O]ld Prairie Du Pont [sic] Creek floodway, located south of Cahokia. The floodway in turn discharges to the Cahokia Chute of the Mississippi River. ... Creek Segment A is isolated from

the remainder of Dead Creek because the culvert under Queeny Avenue has been blocked with concrete. CS-A drains to an interceptor at the north end of the Cerro property. Water from this interceptor is carried to the Sauget Waste Water Treatment Plant. The culvert is partially blocked a the south end of CS-B, and flow from this Segment to the remainder of the creek is restricted. Although the degree of this restriction has not been evaluated, it is known that water does not usually flow through this culvert."

1.1.5. Geology

Geraghty and Miller (1992) described site geology as follows: "The site(s) is situated on the floodplain of the Mississippi River. The floodplain is locally named the American Bottoms and contains unconsolidated valley fill deposits composed of recent alluvium (Cahokia Alluvium), which overlies glacial material (Henry Formation). Published information indicates that these unconsolidated deposits are underlain by bedrock of Pennsylvanian and Mississippian age consisting of limestone and dolomite with lesser amounts of sandstone and shale.

The Cahokia Alluvium (recent deposits) consists of unconsolidated, poorly sorted, fine-grained materials with some local sand and clay lenses. These recent alluvium deposits unconformably overlie the Henry Formation which is Wisconsinian glacial outwash in the form of valley train deposits. The Henry Formation is about 100 feet thick. These valley-train materials are generally medium to course sand and gravel and increase in grain size with depth."

1.1.6. Water resources

Domestic water supply. Ecology and Environment (1988) conducted an evaluation of ground water and surface water resources and the results of this evaluation are summarized below.

"The primary source of drinking water for area residents is an intake in the Mississippi River. This intake is located at river mile 181, approximately 3 miles north of the DCP [Dead Creek Project] study area. The drinking water intake is owned and operated by the Illinois American Water Company (IAWC) of East St. Louis, and it serves the majority of residences in the DCP area. IAWC supplies water to ... Sauget .... The Commonfields of Cahokia Public Water District purchases water from IAWC and distributes it to portions of Cahokia and Centerville Township. The Cahokia Water

Department also purchases water from IAWC and distributes it to small residential areas in the west and southwest portions of Cahokia.

A review of IDPH and ISGS files indicated that at least 50 area residences [within a 3 mile radius of the site] have wells which are used for drinking water or irrigation purposes. These wells are located in Cahokia (23) ....The nearest private wells to any of the DCP sites are located on Judith Lane, immediately south of the Area 1 sites. Based on interviews with these well owners, only one of the five wells located in this area is used occasionally as a source of drinking water and the other four are never used for this purpose.

In summary, although the majority of residences in the general project area are serviced by public water supply systems, well over 50 homes [within a 3 mile radius of the site] utilize private well supplies for drinking water or irrigation purposes."

Industrial water supply. Ecology and Environment (1988) also described industrial water usage. "Industrial groundwater usage has been very extensive in the past. Peak use occurred in 1962 when groundwater pumpage exceeded 35 million gallons per day (mgd). Relatively few industries utilize well-supplied groundwater for process or cooling water. Total groundwater pumpage from industrial sources in the project area [3 mile radius] is estimated to be less than 0.5 mgd." [Note: Ground water usage is probably even lower today given the decline in the regions industrial base.]

Downstream surface water intakes. Ecology and Environment (1988) indicated that "the nearest downstream surface [water] intake on the Illinois side of the Mississippi River is located at river mile 110, approximately 64 miles south of the project area. This intake supplies drinking water to residents in the Town of Chester and surrounding areas in Randolf County, Illinois. The nearest potentially impacted public water supply on the Missouri side of the river is located at river mile 149, approximately 28 miles south of the DCP area. The Village of Crystal City, Missouri (pop. 4,000) located 28 miles south of the DCP area, utilizes a Ranney well adjacent to the Mississippi River as a source for drinking water. Although this is not actually a surface water intake, it is assumed that the well draws water from the river due to its construction and location adjacent to the river."

Agricultural water supply. Ecology and Environment (1988) reported that "Although agricultural land is found throughout the immediate project area,

this land is apparently not irrigated. The nearest irrigated land, other than residential lawns and gardens, is located in the Schmids Lake-East Carondelet area [south of Old Prairie du Pont Creek which is the end of Sauget Area 1]."

1.1.7. Existing fill area information

USEPA Region V, IEPA, Monsanto/Solutia and Cerro Copper have collected a considerable amount of information on soil, ground water, surface water, and sediment in Sauget Area 1. Information included in the January 19, 1999 AOC is given verbatim below. The location of Sites G, H, I, L, M, and N and Creek Segments B, C, D, E, and F are shown on Figure 1.

Site G. "Located south of Queeny Avenue, east of (and possibly under) the Wiese Engineering facility, and north of a cultivated field in the Village of Sauget. CS-B of Dead Creek is located along the eastern boundary of the Site. This site is approximately 5 acres in size and it was operated and served as a disposal area from approximately 1952 to the late 1980's. The Site was fenced in 1988 pursuant to a U.S. EPA removal action under CERCLA which was funded by potentially responsible parties, including Monsanto. On information and belief, wastes located on the surface and/or in the subsurface of Site G have spontaneously combusted and/or burned for long periods of time on several occasions. U.S. EPA conducted a second CERCLA removal action at Site G in 1995. This removal action involved the excavation of PCB, organics, metals, and dioxin contaminated soils on and surrounding Site G, solidification of open oil pits on the Site, and covering part of the Site (including the excavated contaminated soils) with a clean soil cap approximately 18 to 24 inches thick. Site G is enclosed by a fence and is not currently being used. The property is vegetated.

Site G operated as a landfill from approximately 1952 to 1966. The site was subject to intermittent dumping thereafter until 1988, when the Site was fenced. There is an estimated 60,000 cubic yards of wastes within Site G, including oil pits, drums containing wastes, paper wastes, documents and lab equipment. Soil samples collected from Site G revealed elevated levels of VOCs such as chloroform (11,628 ppb), benzene (45,349 ppb), tetrachloroethene (58,571 ppb), chlorobenzene (538,462 ppb), and total xylenes (41,538 ppb). Soil samples also revealed elevated levels of semi-volatile organic compounds (SVOCs) such as phenol (177,800 ppb), naphthalene (5,428,571 ppb), 2,4,6-trichlorophenol (49,530 ppb), and pentachlorophenol (4,769,231 ppb). Elevated levels of the pesticide 4,4-DDE were detected up to 135,385 ppb. Elevated levels of PCBs were detected at levels as high as 174,419 ppb (Aroclor 1248) and 5,300,000 ppb (Aroclor

1260). Dioxin levels in soils at Site G were detected at levels as high as 44,974 ppb. Metals were detected at elevated concentrations such as arsenic (123 ppm), barium (45,949 ppm), copper (2,215 ppm), lead (3,123 ppm), mercury (34.3 ppm), nickel (399 ppm), and zinc (4,257 ppm). Samples collected from wastes which appeared to be a pure solid product material on Site G revealed PCB levels as high as 3,000,000 ppb and dioxin levels in excess of 50,661 ppb.

Groundwater samples collected from beneath Site G revealed elevated levels of VOCs such as trans-1,2-dichloroethene (200 ppb), 1,2-dichloroethane (480 ppb), trichloroethene (800 ppb), benzene (4,100 ppb), tetrachloroethene -L420 ppb), toluene (7,300 ppb), and ethyl benzene (840 ppb). Elevated levels of SVOCs were detected such as 1,2,4-trichlorobenzene (1,900 ppb), naphthalene (21,000 ppb), 4-chloroaniline (15,000 ppb), and 2,4,6-trichlorophenol (350 ppb). An elevated concentration of PCBs was detected at 890 ppb (Aroclor 1260). Elevated metals in groundwater beneath Site G included arsenic (179 ppb), mercury (2.1 ppb), nickel (349 ppb), zinc (1,910 ppb) and cyanide (350 ppb)."

Site H. "Located south of Queeny Avenue, west of Falling Springs Road and west of the Metro Construction Company property in the Village of Sauget, it occupies approximately 5 to 7 acres of land. The southern boundary of Site H is not known with certainty but it is estimated that the fill area extends approximately 1,250 feet south of Queeny Avenue. Site H is connected to Site I under Queeny Avenue and together they were known to be part of the Sauget-Monsanto Landfill [Note: Sauget used to be known as Monsanto until the name of the village was changed] which operated from approximately 1931 to 1957. Site H is not currently being used and the property is graded and grass-covered with some areas of exposed slag.

Due to the physical connection to Site I, waste disposal at Site H was similar to that at Site I. Chemical wastes were disposed of here from approximately 1931 to 1957. Wastes included drums of solvents, other organics and inorganics, including PCBs, para-nitro-aniline, chlorine, phosphorous pentasulfide, and hydrofluosilic acid. Municipal wastes were also reportedly disposed of at Site H. The estimated volume of wastes in Site H is 110,000 cubic yards. There is no containment beneath Site H. Soil samples collected at Site H revealed elevated levels of VOCs such as benzene (61,290 ppb), tetrachloroethene (5,645 ppb), toluene (76,450 ppb), chlorobenzene (451,613 ppb), ethyl benzene (12,788 ppb), and total xylenes (23,630 ppb). Elevated

levels of SVOCs were also found in soil samples such as 1,4-dichlorobenzene (30,645,161 ppb), 1,2 dichlorobenzene (19,354,839 ppb), 1,2,4-trichlorobenzene (7,580,645 ppb), 4-nitroaniline (1,834,000 ppb), phenanthrene (2,114,000 ppb), and fluoranthene (1,330,000 ppb). Soil samples also revealed elevated levels of PCBs such as Aroclor 1260 (18,000,000 ppb), and pesticides 4,4-DDE (780 ppb), 4,4-DDD (431 ppb), and 4,4-DDT (923 ppb). Elevated levels of metals were found such as arsenic (388 ppm), cadmium (294 ppm), copper (2,444 ppm), lead (4,500 ppm), manganese (36,543 ppm), mercury (3.9 ppm), nickel (15,097 ppm), silver (44 ppm), and zinc (39,516 ppm).

Groundwater samples collected from beneath Site H revealed elevated levels of VOCs such as chloroform (3,000 ppb), benzene (4,300 ppb), and toluene (7,300 ppb). Elevated levels of SVOCs were detected in groundwater such as phenol (950 ppb) and pentachlorophenol (650 ppb). An elevated level of PCBs (Aroclor 1260 at 52 ppb) was also detected in groundwater at Site H. Elevated levels of metals were also detected in groundwater such as arsenic (8,490 ppb), copper (2,410 ppb), nickel (17,200 ppb) and cyanide (480 ppb)."

Site I. "Located north of Queeny Avenue, west of Falling Springs Road and south of the Alton & Southern Railroad in the Village of Sauget it occupies approximately 19 acres of land. Segment CS-A of Dead Creek borders Site I on the Site's western side. The site is currently graded and covered with crushed stone and used for equipment and truck parking. Site I was originally used as a sand and gravel pit which received industrial and municipal wastes. Site I is connected to Site H (see below) under Queeny Avenue and together they were known to be part of the "Sauget-Monsanto Landfill." The landfill operated from approximately 1931 to 1957. On information and belief, wastes from Site I leached and/or were released into CS-A and available downstream creek segments until CS-A was remediated in 1990. [Note: The culvert between Creek Segment A and Creek Segment B was blocked in the 1970s.] On information and belief, Site I served as a disposal area for contaminated sediments from historic dredgings of Dead Creek Segment A.

On information and belief, this site accepted chemical wastes from approximately 1931 to the late 1950's. Municipal wastes were also disposed of in Site I. Site I contains approximately 250,000 cubic yards of contaminated wastes and fill material. No subsurface containment is in place beneath Site I. Soil samples collected from Site I have revealed elevated levels of volatile organic compounds (VOCs) such as 1,1,1-trichloroethane (1,692 ppb), trichloroethene (3,810 ppb), benzene (24,130 ppb), tetrachloroethene (5,265 ppb), toluene (77,910 ppb), chlorobenzene (126,900 ppb), ethyl benzene (15,070 ppb), and total xylenes (19,180 ppb). Soil samples also

revealed elevated levels of SVOCs such as 1,3-dichlorobenzene (70,140 ppb), 1,4 dichlorobenzene (1,837,000 ppb), 1,2-dichlorobenzene (324,000 ppb), naphthalene (514,500 ppb), and hexachlorobenzene (1,270,000 ppb). Soil samples also revealed elevated levels of polychlorinated biphenyls (PCBs), such as Aroclor 1260 (342,900 ppb), and the pesticides 4,4-DDD (29,694 ppb), 4,4-DDT (4,305 ppb) and toxaphene (492,800 ppb). Elevated levels of metals were also found in soils, such as beryllium (1,530 ppm), copper (630 ppm), lead (23,333 ppm), zinc (6,329 ppm) and cyanide (3,183 ppm).

Groundwater samples collected from beneath Site I have revealed elevated levels of VOCs such as vinyl chloride (790 ppb), trichloroethene (279 ppb), benzene (1,400 ppb), tetrachloroethene (470 ppb), toluene (740 ppb), and chlorobenzene (3,100 ppb). Elevated levels of SVOCs were also detected in groundwater, such as phenol (1,800 ppb), bis-(2-chloroethoxy)methane (2,900 ppb), 1, 2, 4-trichlorobenzene (2,700 ppb), 4-chloroaniline (9,600 ppb), and pentachlorophenol (2,400 ppb)."

Site L. "Located immediately east of Dead Creek CS-B and south of the Metro Construction Company property in the Village of Sauget. Site L is the former location of two surface impoundments used from approximately 1971 to 1981 for the disposal of wash water from truck cleaning operations. This site is now covered by black cinders and is used for equipment storage. On information and belief, Site L wastes have migrated into Site M (see below).

This site was originally used as a disposal impoundment from approximately 1971 to 1981. The volume of contaminated fill material in Site L is not known, however, the area of the impoundment is estimated to be 7,600 square feet. There is no known containment of wastes beneath Site L. Soil samples collected at Site L revealed elevated levels of VOCs such as chloroform (20,253 ppb), benzene (4,177 ppb), and toluene (26,582 ppb). Elevated levels of SVOCs were also detected such as 2-chlorophenol (2,152 ppb), pentachlorophenol (58,228 ppb), and di-n-butyl phthalate (2,784 ppb). Total PCBs were found at a level of 500 ppm in soils. Elevated levels of metals were detected such as antimony (32 ppm), arsenic (172 ppm), and nickel (2,392 ppm).

Groundwater samples collected from beneath Site L revealed elevated levels of VOCs such as chloroform (730 ppb) and benzene (150 ppb). SVOCs were also detected in groundwater such as phenol (150 ppb), 2-chlorophenol (130 ppb)., 4-methyl phenol (75 ppb), 2-nitrophenol (41 ppb), and 4-chloroaniline

(60 ppb). Elevated levels of metals in groundwater included arsenic (14,000 ppb), cadmium (32 ppb) and zinc (2,210 ppb)."

Site M. "Located along the eastern side of Dead Creek CS-B (south of Site L) at the western end of Walnut Street in the Village of Cahokia. Site M was originally used as a sand borrow pit (dimensions = 220 feet by 320 feet) in the mid to late 1940's. The pit is hydrologically connected to Dead Creek through an eight-foot opening at the southwest portion of the pit. On information and belief, wastes from CS-B have in the past and potentially continue to migrate into Site M via this connection. The site is currently fenced.

Site M was originally constructed as a sand borrow pit in the mid to late 1940's. This pit is approximately 59,200 square feet in size and previous investigations indicate that approximately 3,600 cubic yards of contaminated sediments are contained within the pit. It is estimated that the pit is approximately 14 feet deep and it is probable that there is a hydraulic connection between this pit water and the underlying groundwater. Surface water samples collected from Site M revealed elevated levels of VOCs such as chloroform (27 ppb), toluene (19 ppb) and chlorobenzene (33 ppb). SVOCs detected in surface water included phenol (28 ppb), 2-chlorophenol (14 ppb), 2,4-dimethyl phenol (13 ppb), 2,4-dichlorophenol (150 ppb), and pentachlorophenol (120 ppb). Pesticides detected in surface water include dieldrin (0.18 ppb), endosulfan II (.06 ppb), 4,4-DDT (0.24 ppb), 2,4-D (47 ppb) and 2,4,5-TP (Silvex) (3.4 ppb). PCBs were also detected in surface water at a maximum level of 0.0044 ppb

Sediment samples collected from Site M revealed elevated levels of VOCs such as 2-butanone (14,000 ppb), chlorobenzene (10 ppb) and ethyl benzene (0.82 ppb). SVOCs detected in sediments included 1,4-dichlorobenzene (40 ppm), 1,2-dichlorobenzene (26 ppm), 1,2,4-trichlorobenzene (14 ppm), pyrene (27 ppm), fluoranthene (21 ppm), chrysene (12 ppm), and benzo(b)fluoranthene (15 ppm). Total PCB levels were detected as high as 1,100 ppm. Elevated levels of metals were also detected in sediments at Site M, including antimony (41.2 ppm), barium (9,060 ppm), cadmium (47.2 ppm), copper (21,000 ppm), nickel (2,490 ppm), silver (26 ppm), zinc (31,600 ppm), lead (1,910 ppm), arsenic (94 ppm) and cyanide (1.3 ppm)."

Site N. "Located along the eastern side of Dead Creek CS-C, south of Judith Lane and north of Cahokia Street in the Village of Cahokia. This Site encompasses approximately 4 to 5 acres of previously excavated land used to dispose of concrete rubble and demolition debris. The excavation began in the 1940's and the site is currently inactive and fenced.

Initially developed as a borrow pit in the 1940's, this Site has been filled with concrete rubble, scrap wood and other demolition debris. The depth of the fill may be as much as 30 feet and it occupies approximately 4 to 5 acres of land. Soil samples collected from Site N revealed the presence of SVOCs such as phenanthrene (434 ppb), fluoranthene (684 ppb), and pyrene (553 ppb). An elevated level of mercury (9 ppm) was also detected in soil at Site N."

1.1.8. Existing Dead Creek information

"Dead Creek stretches from the Alton & Southern Railroad at its northern end and flows south through Sauget and Cahokia for approximately 3.5 miles before emptying into the Old Prairie du Pont Creek, which flows approximately 2,000 feet west into a branch of the Mississippi River known as the Cahokia Chute. For many years, Dead Creek has been a repository for local area wastes. On December 21, 1928, an easement agreement between local property owners and representatives of local business, municipal and property interests was executed to "improve the drainage in that District (Dead Creek) by improving Dead Creek so as to make it suitable for the disposal of wastewater, industrial waste, seepage and storm water." Thereafter, Dead Creek systematically received direct and indirect discharges from local businesses and from the Village for many years to come.

Creek Segment CS-A is the northernmost segment of the creek. It is approximately 1800 feet long and 100 feet wide, running from the Alton & Southern Railroad to Queeny Avenue. This segment of the creek originally consisted of two holding ponds which were periodically dredged. For several years, CS-A and available downstream segments (*e.g.*, ones that were not blocked off) received direct wastewater discharges from industrial sources and served as a surcharge basin for the Village of Sauget (formerly the Village of Monsanto) municipal sewer collection system. When the system became backed up or overflowed, untreated wastes from industrial users of the sewer system were discharged directly into CS-A. On several occaisions, CS-A was dredged and contaminated sediments were disposed of onto adjacent Site I. In 1968, the Queeny Avenue culvert, which allowed creek water to pass from CS-A to CS-B, was permanently blocked by the Village of Sauget.

Remediation work was conducted by Cerro Copper in CS-A in 1990. Approximately 27,500 tons of contaminated sediments were removed to

RCRA and TSCA permitted facilities. CS-A is now filled and covered with crushed gravel. Land use surrounding CS-A is industrial.

Creek Segment CS-B extends for approximately 1800 feet from Queeny Avenue to Judith Lane. Sites G, L, and M border this creek segment. Land use surrounding CS-B is primarily commercial with a small residential area near the southern end of this segment. Agricultural land lies to the west of the creek and south of Site G. In 1965, the Judith Lane culvert, which allowed creek water to pass from CS-B to CS-C, was blocked. CS-B is hydrologically connected to Site M by a man-made ditch (see above).

Creek Segment CS-C extends for approximately 1300 feet from Judith Lane south to Cahokia Street. Site N borders this creek segment. Land use is primarily residential along both sides of CS-C.

Creek Segment CS-D extends for approximately 1100 feet from Cahokia Street to Jerome Lane. Land use is primarily residential along both sides of CS-D.

Creek Segment CS-E extends approximately 4300 feet from Jerome Lane to the intersection of Illinois Route 3 and Route 157. Land use surrounding CS-E is predominantly commercial with some mixed residential use. Dead Creek temporarily passes through corrugated pipe at the southern end of CS-E.

Creek Segment CS-F is approximately 6500 ft long and extends from Route 157 to the Old Prairie du Pont Creek. CS-F is the widest segment of Dead Creek, and a large wetland area extends several hundred feet out from both sides of the creek.

Information on the types of wastes disposed of and the types and levels of contamination found at the Sauget Area 1 Site have been provided to USEPA Region V from various sources, including, but not exclusively from: 1) CERCLA 103(c) Submittals; 2) CERCLA 104(e) Responses; 3) Expanded Site Investigation Dead Creek Project Sites (Ecology and Environment, 1988); 4) Removal Action Plan for Dead Creek Sites (Weston-SPER, 1987); 5) Description of Current Situation at the Dead Creek Project Sites (Ecology and Environment, 1986); 6) Site Investigations for Dead Creek Segment B and Sites L and M (Geraghty & Miller, Inc. 1992); 7) Site Investigation/Feasibility Study for Creek Segment A (Advent Group, 1990); 8) Preliminary Ecological Risk Assessment for Sauget Area 1, Creek Segment F (Ecology and Environment, 1997); 9) EPA Removal Action Report for Site G (Ecology and Environment 1994); 10) Area One Screening Site Inspection Report; and 11)

Site Investigation Feasibility Study for Creek Segment A (Advent Group 1990)."

Creek Segment A. "Approximately 20,000 cubic yards of contaminated material were removed from this segment of Dead Creek in 1990, and the area was then backfilled with clean material. The assumption that only low-levels of residual contamination may currently exist within CS-A is yet to be confirmed. Prior to remediation activities, soil and sediment samples collected from CS-A revealed elevated levels of VOCs such as 1,2-dichloroethene (15,000 ppb), trichloroethene (100,000 ppb), tetrachloroethene (11,000 ppb), chlorobenzene (31,000 ppb), ethyl benzene (80,000 ppb), and xylene (500,000 ppb). Elevated levels of SVOCs detected in soils and sediments included 1,3--dichlorobenzene, 4-chloroaniline (17,000 ppb), acetophenone (24,000 ppb), 1, 2, 4, 5-tetrachlorobenzene (28,000 ppb), pentachlorobenzene (37,000 ppb), phenathrene (14,000 ppb), and pyrene (10,000 ppb). Elevated levels of PCBs (total) were also detected at a maximum concentration of 3,145,000 ppb. Elevated levels of metals were also detected in soils and sediments in CS-A including silver (348 ppm), arsenic (194 ppm), cadmium (532 ppm), copper (91,800 ppm), mercury (124 ppm), nickel (6,940 ppm), lead (32,400 ppm), antimony (356 ppm), selenium (41.6 ppm), and zinc (26,800 ppm)."

Creek Segment B. "Elevated levels of VOCs and SVOCs were detected in sediment samples collected from CS-B such as benzene (87 ppb), toluene (810 ppb), chlorobenzene-(5,200 ppb), ethyl benzene (3,600 ppb), trichlorobenzene (3,700 ppm), dichlorobenzene (12,000 ppm), chloronitrobenzene (240 ppm), xylenes (540 ppm), 1,4-dichlorobenzene (220,000 ppb), 1,2-dichlorobenzene (17,000 ppb), phenanthrene (15,000 ppb), fluoranthene (11,000 ppb), pyrene (13,000 ppb). Elevated levels of PCBs exist within CS-B at levels as high as 10,000 ppm. Elevated levels of metals were also detected in sediments in CS-B including arsenic (6,000 ppm), cadmium (400 ppm), copper (44,800 ppm), lead (24,000 ppm), mercury (30 ppm), nickel (3,500 ppm), silver (100 ppm), and zinc (71,000 ppm).

Surface water samples collected from CS-B revealed elevated concentrations of VOCs such as chloroform (27 ppb), 1,1-dichloroethene (3 ppb), toluene (20 ppb), and chlorobenzene (33 ppb). SVOCs detected in surface water included phenol (28 ppb), 2-chlorophenol (14 ppb), 1,4-dichlorobenzene, 2-methyl phenol (4 ppb), 4-methyl phenol (35 ppb), 2,4-dichlorophenol (150 ppb), naphthalene (8 ppb), 3-nitroaniline (9 ppb), and pentachlorophenol (120 ppb). Pesticides were also detected in surface water samples including dieldrin (0.18

ppb), 4,4-DDT (0.24 ppb), 2,4-D (47 ppb) and Silvex (3.4 ppb). An elevated level of PCBs (Aroclor 1260) was also detected in the surface water of CS-B at a level of 44 ppb. Elevated levels of metals were detected in surface water such as aluminum (9,080 ppb), barium (7,130 ppb), arsenic (31 ppb), cadmium (25 ppb), chromium (99 ppb), copper (17,900 ppb), lead (1,300 ppb), mercury (8.6 ppb), nickel (1,500 ppb), and zinc (10,300 ppb)."

Creek Segment C. "Elevated levels of VOCs and SVOCs were detected in sediments in this segment of Dead Creek including fluoranthene (4,600 ppb), pyrene (4,500 ppb), benzo(a)anthracene (3,300 ppb), chrysene (4,400 ppb), benzo(b)fluoranthene (7,500 ppb), benzo(a)pyrene (4,500 ppb), indeno(1,2,3-cd)pyrene (4,300 ppb), benzo(g, h, l) perylene (1,500 ppb), dibenzo(a, h)anthracene (4,000 ppb), and 4-methyl-2-pentanone (1,200 ppb). PCBs (total) were also detected in sediments from CS-C at a maximum concentration of 27,500 ppb. Sediment samples also revealed elevated levels of metals such as copper (17,200 ppm), lead (1,300 ppm), nickel (2,300 ppm), zinc (21,000 ppm) and mercury (2.81 ppm).

Surface water samples collected from creek segment CS-C revealed elevated levels of metals such as lead (710 ppb), mercury (1.9 ppb), and nickel (83 ppb)."

Creek Segment D. "Elevated concentrations of VOCs and SVOCs were detected in sediment samples collected from CS-D including 4-methyl-2-pentanone (1,200 ppb), benzo(b)fluoranthene (500 ppb), indeno(1, 2, 3-cd)pyrene (310 ppb), and dibenzo(a, h)anthracene (360 ppb). PCBs (total) were detected in sediments at a maximum concentration of 12,000 ppb. Elevated concentrations of metals were also detected such as cadmium (42 ppm), copper (1,630 ppm), lead (480 ppm), mercury (1 ppm), and zinc (6,590 ppm).

Surface water samples collected from CS-D revealed elevated concentrations of metals such as cadmium (8.1 ppb), lead (89 ppb), and nickel (189 ppb)."

Creek Segment E. "Elevated concentrations of VOCs and SVOCs were detected in sediment samples collected from CS-E including chlorobenzene (120 ppb), pyrene (5,300 ppb), benzo(b)fluoranthene (2,400 ppb), and chrysene (2,800 ppb). Elevated levels of PCBs (total) were also detected at a maximum concentration of 59,926 ppb. Elevated levels of metals were also detected in the sediments of CS-E including cadmium (23.1 ppm), copper (8,540 ppm), lead (1,270 ppm), mercury (1.53 ppm), nickel (2,130 ppm), and zinc (9,970 ppm)."

Creek Segment F. "Elevated concentrations of VOCs and SVOCs were detected in the sediments of CS-F such as toluene (29 ppb), 4-methyl phenol (1,100 ppb), fluoranthene (310 ppb), and pyrene (340 ppb). Pesticides were also detected in the sediments such as 4,4-DDE (97 ppb), endrin (66 ppb), endosulfan 11 (203 ppb), and methoxychlor (8 ppb). PCBs (total) were also detected in sediments at a maximum concentration of 5,348 ppb. Elevated levels of metals were also detected in the sediments such as arsenic (276 ppm), lead (199 ppm), mercury (0.55 ppm), cadmium (23.5 ppm), copper (520 ppm), nickel (772 ppm) and zinc (4,520 ppm). Elevated concentrations of dioxins were also detected in sediments in CS-F at a maximum concentration of 211 picograms per gram."

1.1.9. Existing data

In 1998, Ecology and Environment prepared a report (Sauget Area 1 Data Tables/Maps) for USEPA Region V that "summarized existing technical and potentially responsible party (PRP) data for each subunit of the sites along with other information compiled during Ecology and Environment's file searches of various agencies and organizations." This report contains the following information obtained from work done by Illinois EPA (IEPA), Ecology and Environment (E&E), Weston, Geraghty & Miller (G&M) and The Advent Group.

Volume 1 - Sauget Area 1

Introduction
Report Organization
Site G
- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - Organics and Metals (IEPA, 1984)
  - Surface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1986)
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)
  - Soil Samples - PCB and PCP (Weston, 1987)
  - Waste/Soil Samples - Metals and Organics (IEPA, 1984)
  - Soil Samples - VOCs (G&M, 1991)
  - Soil Samples - BNAs, Metals, Pesticides/PCBs (E&E, 1986)

- Soil Samples - VOCs, BNAs, Pesticides/PCBs (IEPA, 1994)

Site H
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)

Site L
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)
  - Soil Samples - PCBs (IEPA, 1981)
  - Sediment Samples - VOCs, BNAs, PCBs, Metals (G&M, 1991)
  - Subsurface Soil Samples - TCLP Metals, VOCs, BNAs, Pesticides/PCBs (G&M, 1991)

Site I
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)

Creek Segment A
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)
  - Sediment Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Surface Water Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1986)
  - Soil Samples - PCBs, Metals (IEPA, 1981)
  - Sediment Samples - Metals and Organics (IEPA, 1981)
  - Surface Water Samples - Metals and Organics (IEPA, 1981)
  - Soil/Sediment Samples - VOCs, BNAs, PCBs, PCB Precursors, Metals (Advent Group, 1990)

Site M
- Site Narrative
- Analytical Data Summaries
  - Surface Water Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Sediment Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1986)
  - Sediment/Surface Water Samples - VOCs, BNAs, Metals, PCBs, RCRA Hazardous Characteristic Parameters (G&M, 1992)

- Water/Sediment Samples - Metals and Organics (IEPA, 1980)
- Surface Water Samples - VOCs, BNAs, Pesticides/PCBs, Metals, Herbicides (IEPA, 1994)
- Soil/Sediment Samples - Metals (IEPA, 1980)

Creek Segment B
- Site Narrative
- Analytical Data Summaries
  - Sediment Soil Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Surface Water Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Sediment Samples - BNAs, VOCs, Metals (G&M, 1991)
  - Soil/Sediment Samples - Metals, Pesticides/PCBs, VOCs, BNAs (G&M, 1991)
  - Sediment Samples - RCRA Hazardous Characteristic Parameters (G&M, 1991)
  - Soil Sediment Samples - Organics, Phosphorus, Metals (IEPA/Monsanto, 1980)
  - Surface Water Sample - Metals (Eastep, 1975)
  - Surface Water Samples - VOCs, BNAs, Metals, Pesticides/PCBs (IEPA, 1993/94)
  - Soil/Sediment Samples - Metals, Organics (IEPA, Sept. 1980)
  - Soil/Sediment Samples - Metals, Organics (IEPA, Oct. 1980)

Site N
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1986)

Creek Segment C
- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Surface Water Samples - VOCs, BNAs, Pesticides/PCBs, Metals, (E&E, 1986)
  - Sediment/Soil Samples - Metals and Organics (IEPA, 1980)
  - Water Samples - Metals and Organics (IEPA, 1980)
  - Soil Samples - Metals and Organics (IEPA, 1991)
  - Sediment Samples - Metals (IEPA, 1980)

- Surface Water Samples - VOCs, BNAs, Metals, Pesticides/PCBs (IEPA, 1993)
- Water Samples - Metals (IEPA, 1980)

Creek Segment D
- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Surface Water Samples - VOCs, BNAs, Pesticides/PCBs, Metals, (E&E, 1986)
  - Sediment Samples - VOCs, SVOCS, Pesticides/PCBs, Inorganics, Metals (IEPA, 1991)

Creek Segment E
- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - VOCs, SVOCS, Pesticides/PCBs, Inorganics, Metals (IEPA, 1991)
  - Sediment Samples - Metals and Organics (IEPA, 1980)
  - Water Samples - Metals and Organics (IEPA, 1980)
  - Sediment Samples - Metals (IEPA, 1980)
  - Water Samples - Metals (IEPA, 1980)

Creek Segment F
- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - Metals, PCBs (E&E, 1997)
  - Soil/Sediment Samples - VOCs, SVOCs, Pesticides/PCBs (IEPA, 1991)
  - Sediment Samples - VOCs, SVOCs, Pesticides/PCBs, Inorganics, Metals (IEPA, 1991)
  - Soil/Sediment Samples - Metals and Organics (IEPA, 1990)

Area 1 Groundwater
- Site Narrative
- Creek Segment B - Metals/Indicators (IEPA, 1980)
- Site G - VOCs, BNAs, Metals (E&E, 1987)
- Site H - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)
- Site I - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1987)
- Site L - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1987)
- Private Wells - VOCs, BNAs, Pesticide/PCBs, Metals (E&E, 1987)
- Groundwater Monitoring Survey - Organics and Metals (IEPA, 1982)
- Monitoring Well Samples - Metals, Pesticides/PCBs (IEPA, 1980 and 1983)
- Groundwater Samples - VOCs, SVOCs, Pesticides/PCBs, Inorganics (IEPA, 1991)

Water Samples - PCBs (IEPA and Monsanto, 1980)
Groundwater Samples - Metals and Organics (IEPA, 1981)
Groundwater Samples - Metals and Organics (IEPA, 1981)
Groundwater Samples - VOCs, SVOCs, Pesticides/PCBs, Metals (IEPA, 1991)

The 1998 Ecology and Environment Sauget Area 1 Data Tables/Maps Report is not included in the SSP at the request of the Agency. A summary of this information will be included in the Support Sampling Plan Data Report.

1.1.10. Existing risk assessments

In 1997 Ecology and Environment prepared the report "Preliminary Ecological Risk Assessment for Sauget Area 1, Creek Segment F, Sauget, St. Clair County, Illinois". Ecology and Environment "was tasked by the United States Environmental Protection Agency (U.S. EPA) to prepare a screening-level ecological risk assessment for the Sauget Area 1, Creek Segment F site ... The objective of this report is to determine whether the site poses no immediate or long-term ecological risk, or if a potential ecological risk exists and further evaluation is necessary."

Conclusions and recommendations of the report are given below:

"Based on this investigation, site contamination does not appear to threaten human health. Sediment contamination levels are below risk-based values and few people enter the site boundaries.

Elevated levels of metals and PCBs may be highly detrimental to the ecology of this site [Creek Segment F]. The presence of arsenic, cadmium, and dioxin greater than SEL guidelines may decrease the species richness of the area. Sensitive species, including the endangered Black-Crowned Night Heron, inhabit the site and therefore, are subject to effects such as acute toxicity, reduced growth, inhibited reproduction, and other adverse effects. Finally, species that feed on contaminated organisms may bioaccumulate the contaminants and become adversely affected.

The contamination on the site [Creek Segment F] warrants further investigation and possible remediation, especially because it provides high quality wetland habitat."

This report is included in the SSP as Appendix A.

2. Project organization and responsibilities

O'Brien & Gere will perform the field activities, prepare the report, and provide project management. Analytical services for this SSP will be provided by Savannah Labs & Environmental Services, Inc. (Savannah Labs) in Savannah, Georgia. Analytical services for dioxin and dibenzofuran for this Support Sampling Project will be provided by Triangle Laboratories, Inc. (Triangle Labs) in Durham, North Carolina. The responsibilities of key project personnel are described below. The responsibilities of key laboratory personnel are described in section 2.5 of the QAPP.

2.1. Project organization

Sections 2.2 through 2.4 of this FSP present the responsibilities of the key project personnel and the lines of authority for the project personnel are described in each section.

2.2. Management responsibilities

2.2.1. USEPA Region V remedial project manager

Michael McAteer will serve as the USEPA Region V Remedial Project Manager (USEPA RPM). As such, he will have overall responsibility for all phases of the Support Sampling Project.

2.2.2. Illinois Environmental Protection Agency (IEPA) remedial project manager

Candy Morin will serve as IEPA Remedial Project Manager.

2.2.3. Solutia Inc. remedial project manager

Bruce S. Yare, of Solutia will serve as the Solutia RPM. As such, he will have the overall responsibility for all phases of the Support Sampling Project. He will be responsible for implementing the project, and will have the authority to commit the resources necessary to meet project objectives and requirements. The Solutia RPM's primary function is to verify that technical, financial, and scheduling objectives are achieved successfully. The Solutia RPM will report directly to USEPA Region V and will provide the major point of contact and control for matters concerning the project. The Solutia RPM will:

- Define project objectives and develop a work plan schedule
- Establish project policy and procedures to address the specific needs of the project as a whole, as well as the objectives of each task
- Acquire and apply technical and corporate resources as needed to verify performance within budget and schedule constraints
- Monitor and direct the field leaders
- Develop and meet ongoing project staffing requirements
- Review the work performed on each task to verify its quality, responsiveness, and timeliness
- Review and analyze overall task performance with respect to planned requirements and authorizations
- Approve all reports before their submission to USEPA Region V
- Ultimately be responsible for the preparation and quality of reports
- Represent the project team at meetings.

2.2.4. O'Brien & Gere project officer

Dean L. Palmer, PE, will serve as the O'Brien & Gere Project Officer. As such, he is responsible for the overall administration and technical execution of the project. He will report directly to the Solutia RPM.

2.2.5. O'Brien & Gere project manager

Alan J. Cork, PE, will serve as the O'Brien & Gere Project Manager (PM). As such, he will have overall responsibility for verifying the project meets USEPA Region V's objectives and O'Brien & Gere's quality standards. He will provide assistance to the Solutia RPM in terms of writing and distributing the QAPP to those parties connected with the project (including the

laboratory). He will report directly to the O'Brien & Gere Project Officer and is responsible for technical quality control and project oversight.

2.3. Quality assurance (QA) responsibilities

2.3.1. Environmental Standards data validator

Kathy Blaine of Environmental Standards in Belleville, Illinois will serve as the third-party data validator. As such, she will remain independent of direct job involvement and day-to-day operations, and have direct access to corporate executive staff, as necessary, to resolve QA dispute. The data validator will be responsible for auditing the implementation of the QA program in conformance with the demands of specific investigations, O'Brien & Gere's policies, and USEPA Region V requirements. The specific functions include:

- Providing QA audits on various phases of the field operations
- Reviewing and approving the QA plans and procedures
- Reporting on the adequacy, status, and effectiveness of the QA program on a regular basis to the Solutia RPM
- Data validation of all sample results from the analytical laboratory.

2.3.2. O'Brien & Gere QA officer

Karen Storne will serve as the O'Brien & Gere QA Officer (QAO). As such, she will report directly to the O'Brien & Gere PM and will be responsible for verifying that O'Brien & Gere QA procedures for this project are being followed. In addition, she will be responsible for internal laboratory audits. The O'Brien & Gere PM is responsible for field quality assurance activities.

2.3.3. USEPA Region V quality assurance reviewer

Michael McAteer, the USEPA Region V RPM, or a designee, will serve as the USEPA Region V Quality Assurance Reviewer. As such, he will have the responsibility to review and approve the QAPP. In addition, he will be responsible for conducting external performance and system audits of the laboratory and field activities, and review and evaluate analytical laboratory and field procedures.

2.4. Field responsibilities

2.4.1. O'Brien & Gere field leader

David E. Haverdink, or a designee, will serve as the O'Brien & Gere Field Leader. He will be responsible for leading, coordinating, and supervising the day-to-day field activities. His responsibilities include:

- Provision of day-to-day coordination with the O'Brien & Gere PM on technical issues
- Develop and implement field related work plans and schedule
- Coordinate and manage field staff
- Supervise or act as the field sample custodian
- Implement the QC for technical data, including field measurements
- Adhere to work schedules
- Authorize and approve text and graphics required for field team efforts
- Coordinate and oversee technical efforts of subcontractors assisting the field team
- Identify problems at the field team level, resolve difficulties in consultation with the O'Brien & Gere PM, implement and document corrective action procedures, and provide communication between team and upper management
- Prepare the final report.

2.4.2. O'Brien & Gere field team

The technical staff (William E. Wright and Joseph W. Perry) will be drawn from O'Brien & Gere's pool of corporate resources. The technical staff will be utilized to gather and analyze data, and to prepare various task reports and support materials. The technical staff are experienced professionals who possess the degree of specialization and technical competence required to effectively and efficiently perform the required work.

3. Project scope and objectives

The purpose of the SSP is to gather sufficient information from the Sauget Area 1 Site to identify the nature of waste materials in Sites G, H, I, L, M, and N and to assess the extent of constituent migration in soil, ground water, surface water, sediments, and air at the site.

Collected data will be used by others to prepare a Human Health Risk Assessment (HHRA), an Ecological Risk Assessment (ERA), an EE/CA for soil, surface water, sediments, and air, and an RI/FS for ground water. The EE/CA and RI/FS SSP (Solutia Inc. 1999) and this FSP include a description of the sample media, sample locations, number of samples, and analytical methods.

The main components of the SSP addressed in this FSP include:

- Source area sampling (soil gas sampling, waste sampling, buried drum and tank identification)
- Ground water sampling (upgradient, fill areas, down gradient alluvial aquifer, bedrock, domestic wells, slug tests, and grain size analysis)
- Soil sampling (undeveloped areas, developed areas, and background)
- Sediment sampling (undeveloped areas, developed areas, Borrow Pit Lake, and Dead Creek)
- Surface water sampling
- Air sampling
- Pilot test sampling.

Site plans showing sampling locations are located on Figures 1-11 of this FSP.

3.1. Site characterization

The January 21, 1999 Administrative Order on Consent Scope of Work identified the site characterization information needed to define the extent of contamination at Sauget Area 1 for purposes of implementing a removal action on the source areas and Dead Creek and for implementing a remedial action

for ground water. In addition, an analysis of currently available data was done to determine the areas of the Site that required characterization data in order to define the extent of contamination for purposes of implementing a removal action on the source areas and Dead Creek and for implementing a remedial action for ground water.

Sections 5 to 12 of the SSP and section 5 of this FSP address activities designed to provide site characterization data. These chapters describe the number, types, and locations of additional samples that will be collected as part of the SSP.

3.1.1. Waste characterization

The AOC SOW requires inclusion of a program in the SSP for characterizing the waste materials at the Site including an analysis of current information/data on past disposal practices, test pits/trenches, and deep soil borings to determine waste depths and volume and extent of cover over fill areas, soil gas surveys on and around fill areas, and geophysical delineation of potential "hot spot" drum removal areas. Based on the AOC SOW requirements, meetings and telephone conversations with USEPA, USACE, Weston, and IEPA and a review of the 1998 Ecology and Environment report, the identified waste characterization data include:

- Past disposal practices
- Waste depths and volumes
- Extent of cover over fill areas
- Soil gas survey on and around fill areas
- Buried drum and tank identification.

Section 5.0 of the SSP, Waste Characterization Sampling Plan, describes the work that will be performed to obtain waste characterization data. This corresponds to sections 5.1 to 5.5 of the FSP.

3.1.2. Hydrogeology

The AOC SOW requires inclusion of a program in the SSP for performing a hydrogeologic investigation at the Site including assessment of the degree of hazard, regional and local flow direction and quality, and local uses of ground

water. In addition, the SSP was required to develop a strategy for determining horizontal and vertical distribution of contaminants and to include slug tests, grain size analyses and upgradient samples. Based on the AOC SOW requirements, meetings, and telephone conversations with USEPA, USACE, Weston, and IEPA and a review of the 1998 Ecology and Environment report, the identified ground water characterization data include:

- Degree of hazard and mobility of constituents
- Discharge and recharge areas
- Regional and local flow direction and quality
- Local uses of groundwater
- Horizontal and vertical distribution of constituents
- Slug tests
- Grain size analyses
- Upgradient samples.

Section 6.0 of the SSP, Ground Water Sampling Plan, describes the work that will be performed to obtain ground water characterization data. This corresponds to sections 5.6 to 5.16 of the FSP.

3.1.3. Soil

The AOC SOW requires inclusion of a program in the SSP for performing a soil investigation at the Site to determine the extent of contamination of surface and subsurface soils. Sampling of leachate from the fill areas,and sampling of soil in commercial/open areas adjacent to Dead Creek were also required. The AOC SOW indicated that residential soil sampling may also be required depending on the results from the commercial/open area sampling. Based on the AOC SOW requirements, meetings, and telephone conversations with USEPA, USACE, Weston, and IEPA and a review of the 1998 Ecology and Environment report, soil characterization data include:

- Extent of contamination of surface and subsurface soils
- Leachate samples from fill areas
- Soil sampling of residential/commercial areas adjacent to Dead Creek

Section 7.0 of the SSP, Soil Sampling Plan, describes the work that will be performed to obtain soil characterization data. This corresponds to sections 5.17 to 5.19 of the FSP.

3.1.4. Sediment

The AOC SOW requires inclusion of a program in the SSP for performing a sediment investigation at the Site to determine the extent and depth of contaminated sediments in all segments of Dead Creek and its tributaries and surrounding wetland areas. Based on the AOC SOW requirements, meetings, and telephone conversations with USEPA, USACE, Weston, and IEPA and a review of the 1998 Ecology and Environment report, sediment characterization data include:

- Extent and depth of contamination in sediments

Section 8.0 of the SSP, Sediment Sampling Plan, describes the work that will be performed to obtain soil characterization data. This corresponds to section 5.20 of the FSP.

3.1.5. Surface water

The AOC SOW requires inclusion of a program in the SSP to determine the areas of surface water contamination in Dead Creek and its tributaries and surrounding wetland areas. Based on the AOC SOW requirements, meetings, and telephone conversations with USEPA, USACE, Weston, and IEPA and a review of the 1998 Ecology and Environment report, surface water characterization data include:

- Areas of surface water contamination in Dead Creek and its tributaries and surrounding wetland areas.

Section 9.0 of the SSP, Surface Water Sampling Plan, describes the work that will be performed to obtain surface water characterization data. This corresponds to section 5.21 of the FSP.

3.1.6. Air

The AOC SOW requires inclusion of a program in the SSP to determine the extent of atmospheric contamination from the various source areas at the Site and to address the tendency of substances identified through waste characterization to enter the atmosphere, local wind patterns, and their degree of hazard. Based on the AOC SOW requirements, meetings, and telephone

conversations with USEPA, USACE, Weston, and IEPA and a review of the 1998 Ecology and Environment report, air characterization data include:

- Tendency of constituents to enter the atmosphere
- Tendency of constituents to enter local wind patterns
- Degree of hazard.

Section 10.0 of the SSP, Air Sampling Plan, describes the work that will be performed to obtain air characterization data. This corresonds to section 5.22 of the FSP.

3.1.7. Ecological assessment

The AOC SOW requires inclusion of a program in the SSP to collect data for the purpose of assessing the impact, if any, to aquatic and terrestrial ecosystems within and adjacent to Sauget Area 1 resulting from the disposal, release, and migration of contaminants. This program must include a description of ecosystems affected, an evaluation of toxicity, an assessment of endpoint organisms, and exposure pathways. It also must include a description of toxicity testing or trapping to be done as part of the assessment. Based on the AOC SOW requirements, meetings, and telephone conversations with USEPA, USACE, Weston and IEPA and a review of the 1998 Ecology and Environment report, ecological assessment includes:

- Affected ecosystem description
- Evaluation of toxicity
- Assessment of endpoint organisms
- Exposure pathways
- Toxicity testing or trapping.

Section 11.0 of the SSP, Ecological Assessment Sampling Plan, describes the work that will be performed to obtain data for the ecological assessment.

3.1.8. Pilot treatability tests

The AOC SOW requires inclusion of a program in the SSP for any pilot tests necessary to determine the implementability and effectiveness of technologies where sufficient information is not otherwise available. Based on the AOC SOW requirements, meetings, and telephone conversations with USEPA, USACE, Weston, and IEPA and a review of the 1998 Ecology and Environment report, pilot treatability tests include:

- Waste Incineration
- Waste Thermal Desorption
- Sediment Thermal Desorption
- Sediment Stabilization
- Leachate Treatment.

Section 12.0 of the SSP, Pilot Treatability Test Sampling Plan, describes the work that will be performed to perform these pilot treatability tests. This corresponds to section 5.23 of the FSP.

3.2. Project schedule

The estimated project schedule is presented in Volume 1A, section 16.0 of the SSP.

4. Non-measurement data acquisition

4.1. Topographic map and sample location surveying

4.1.1. Topographic map

Surdex, an aerial photography and mapping subcontractor, flew the study area in late March to obtain current aerial photographs of the study area prior to the spring emergence of vegetation. These photographs, combined with ground control surveying, will be used to prepare a topographic map of the study area with a 1 inch = 50 foot scale and a topographic contour interval of 1 ft. This map will consist of seventeen 30-inch by 40-inch sheets, and it will meet National Map Standards with a horizontal accuracy of +/- 1.25 ft and a vertical accuracy for contour lines of +/- 0.5 ft.

4.1.2. Location and elevation surveying

Information submitted to USEPA Region V and IEPA describing sampling locations will be identified in the field using a global positioning satellite (GPS) system capable of producing decimal latitude and longitude readings having a horizontal accuracy of one meter or less. Well elevations will be surveyed to an accuracy of ±0.01 ft. Information submitted to USEPA Region V and IEPA must be in a Microsoft Excel®-compatible electronic spreadsheet and must include columns on:

- Latitude (decimal degrees)
- Longitude (decimal degrees)
- Sample identification
- Sample description (*e.g.*, soil, ground water)
- Locational method
- Sample depth
- Time and date of sample collection
- Time and date of sample analysis

- Chemical parameter
- Chemical result
- Analysis method
- Detection limit
- Chemical units (ppm, ppb, mg/kg, etc.)
- Result qualifier (non-detect, etc.).

4.2. Aerial photograph acquisition and analysis

Available historical air photographs not included in the 1988 Ecology and Environment report will be obtained for Sites G, H, I, L, and N. These photographs, and the results of the E&E evaluation, will be used to define the areal extent of each site. Boundaries of the waste disposal areas will be defined using historical aerial photographs to establish the areal extent of excavation and fill areas over time. For each photo, the boundaries of Sites G, H, I, L, and N will be traced and input into an AutoCAD file. To define the extent of fill, the AutoCAD files will be overlain for each site and a line will be drawn around the outside boundary of the composite fill areas. If stereoscopic evaluation of historical aerial photographs allows identification of the deepest portion of the fill area, one of the four waste characterization borings will be conducted at that location.

Results of the analysis of historical aerial photographs will be used to prepare a map for each site showing fill area boundaries and the final selected locations of the boundary confirmation trenches and the waste characterization borings. When the map for each fill area is completed, it will be submitted to USEPA Region V for acceptance prior to performance of the boundary confirmation trenching or collection of the waste characterization samples.

Boundary confirmation trenches and waste characterization borings will be located in the field by measuring from known points, such as buildings, roads, or other cultural features or by using GPS.

5. Field activities by area of concern

5.1. Source area boundaries delineation - test trenches

5.1.1. Rationale/design

Preliminary boundary confirmation trench and waste characterization boring locations are shown on Figures 2 and 3. Test trenches will be used to confirm the boundaries of the fill areas identified through aerial photograph analysis. One trench will be installed on each side of a fill area, a total of four trenches per site. The four trenches will be located at the midpoint of the four longest sites of the defined boundary. A GPS system will be used to document the locations on aerial site maps. Test trenches will start outside the defined boundary of the fill area and move toward the defined boundary. When fill materials are encountered, the fill area boundary will be considered confirmed and trenching at that location will be terminated. Excavated soil and fill material will be returned to the test trench, with the exception of any intact drums, which will be removed provided confined space entry is not needed to retrieve a drum. Trenches will not be entered to recover drums because of the danger inherent in such activities. Test trench locations will be determined using GPS and recorded for future reference in the event drum removal is appropriate. Drums recovered during trenching activities will be handled by the drum removal contractor in accordance with the requirements of 29 CFR 1910.120 (j). Recovered drums will be overpacked and stored pending disposal. Free product and contaminated soil resulting from rupture of drums during removal will be cleaned up by absorbing any liquid materials and placing the absorbent, solid waste, and contaminated soil in bulk containers at a controlled-access, fenced, investigation-derived waste storage area to be constructed north of Judith Lane adjacent to Dead Creek. Overpacked drums will be also be stored at this facility. Recovered drums will be stored until the capacity of the storage pad is exceeded or the investigation is completed, whichever comes first. Drum and waste storage may be indefinite if they contain materials that can not be accepted by off-site disposal facilities (*e.g.*,

dioxin). Any waste excavated that identifies the source of material present in the fill area will be noted in the field log and photographed.

- Number of test trenches.....20

Sampling locations will be selected in the field with the concurrence of USEPA Region V, or its designee. Trenching equipment will be hired on a per-day basis. If all or part of the planned twenty boundary trenches are finished before the end of a day, additional trenches will be installed at locations directed by USEPA Region V for the remainder of the day, provided these areas are covered by access agreements.

5.1.2. Waste volumes

Waste volume will be established using the areal extent information obtained from historical aerial photo analysis and boundary confirmation trenching and the depth of fill information obtained from the waste characterization borings at each site.

5.1.3. Field procedures

Test trench locations will be selected in the field with the concurrence of USEPA Region V or its designee and noted in the field notebook. A "competent" person," as defined in 29 CFR 1976.650, will observe the trenching activities and will have authorization to take corrective measures to respond to unsanitary, hazardous, or dangerous conditions to workers. To complete the test trenches, a track-mounted hoe with an extended arm will be used to provide the capability to excavate to a maximum depth of 40 ft below grade. All trenching activities will be conducted in a manner to protect existing utilities, structures, surface features, monitoring wells, and the general site environment. Additionally, trenching activities will follow Occupational Safety and Health Administration (OSHA) rules for excavations. A photoionization detector (PID), an explosimeter, and a real time aerosol monitor (RAM) will be used on a continuous basis to monitor the test trenches for hazardous conditions. The hoe operator will have a separate supplied-air system.

Test trenches will be advanced to a maximum depth of 40 ft, where possible. Should ground water infiltration and/or poor soil stability result in the inability to complete a test trench to 40 ft, the trenching will be terminated at that location. No accommodations will be made to dewater test trenches or manage ground water during excavation activities in order to minimize the generation of investigation-derived wastes.

Additionally, should waste materials be encountered during trenching at a boundary, the trenching activities will proceed out and away from the boundary until native soils are encountered. Where native soils are encountered, the excavation will proceed to greater depth up to a maximum of 40 ft below grade, where possible. Should waste materials be encountered again within the test trench, this procedure will be repeated until no waste materials are encountered within the test trench. The location where no additional waste materials are encountered within the test trench will be designated as the extent of the site boundary for that location. As the trenching proceeds, spoils from the test trenches will be placed on polyethylene plastic having a minimum thickness of 6 mil. Provisions will be made to allow free liquids in the spoils to drain back to the trench. Spoils from each test trench will be segregated and returned to the excavation in reverse order of removal. Prior to handling the cover material, the excavator bucket will be grossly decontaminated using a shovel and/or a potable water source. Decontamination debris will be placed into the excavation trench prior to placement of cover material. Backfilling will be conducted in a manner to minimize ponding of water over the trench. A silt fence will be installed around the perimeter of the trench to minimize runoff of surface soils during rain events. A test trench at one location will be backfilled prior to the initiation of a test trench at another location. After completion of site investigation activities, the sites will be revegetated with grass. The silt fence will be maintained until revegetation is completed. Handling of investigation-derived wastes from these activities is discussed in Chapter 9.

5.1.4. Documentation

During trenching activities, a representative of O'Brien & Gere will complete a descriptive log for each test trench completed. At a minimum the following information will be included in the log:

- The date, time, weather conditions, equipment, and personnel on-site
- The total depth, length, and width of the test trench
- The depth and total thickness of distinct soil or lithologic units encountered

- A description of any waste excavated, as well as the identification of the source of the material, where possible
- PID, explosimeter, and RAM readings.

Additionally, the location of the test trenches will be laid out on a plan of the site. Digital photographs will be taken of the test trenches, the test trench walls, and any waste materials excavated. The number and location of each photograph will be identified on the field log for each test trench.

5.2. Soil gas survey

5.2.1. Rationale/design

A soil gas survey will be conducted at Sites G, H, I, L, and N using a shallow soil probe (5 ft) and on-site analysis of collected vapors for VOCs. Soil gas samples will be collected at a frequency of one sample per acre. Each sample will be collected at the center point of each grid cell using the following grid spacings (Figures 5 and 6):

Site	Grid Size	Grid Spacing	Number of Samples
G	400' x 600'	200' x 200'	6
H	400' x 800'	200' x 200'	8
I	400' x 1,200'	200' x 200'	12
L	200' x 200'	200' x 200'	1
N	300' x 300'	200' x 200'	2
		Total number of samples	29

If detectable concentrations of VOCs are found in the fill area soil gas samples, the survey will be extended beyond the boundary of the fill area. A total of twelve additional soil gas samples will be collected at each fill area. Soil gas samples will be collected at 100-ft intervals (0, 100, and 200 ft from the edge of the fill area) along four 200-ft long transects (three samples per

transect); one transect perpendicular to each side of the fill area. If VOCs are detected in soil gas at each of the five fill areas, a total of sixty additional soil gas samples will be collected:

Site	Number of Transects	Number of Samples
G	4	12
H	4	12
I	4	12
L	4	12
N	4	12
Total number of samples		60

If twelve additional soil gas samples are not adequate to define the extent of VOC-containing soils associated with each fill area, additional soil gas samples will be collected at 100-ft intervals along the four sampling transects at each fill area until the limits of the impacted fill are found. If soil gas surveys need to extend into areas for which there are no property access agreements, soil gas sampling will be suspended until access is obtained.

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 1 is a sample and analysis summary for this activity.

5.2.2. QA/QC samples

As this work is to field-screen soil vapors for total VOCs, QA/QC samples such as duplicates will not be collected. The field GC will be calibrated twice daily using the equipment manufacturer's standard operation procedures (SOPs).

5.2.3. Field procedures

A direct push technology will be used to advance a membrane interface probe (MIP) to 5 ft below existing grade. The MIP is a 3-ft long steel tool equipped with a point capable of penetrating relatively soft subsurface materials. Limiting constraints are free water and hard subsurface materials. Enclosed within the steel tubing is a polymer membrane, carrier gas tubes, and electrical

wiring cables. The membrane is heated to 120 degrees Centigrade, allowing the migration of soil gases across the membrane and into the carrier gas chamber. The carrier gas captures the soil gases and feeds the sample directly to the GC. The GC then analyses the sample and provides a report of total VOC concentrations. The estimated detection limit of the field GC for total VOCs is 1 μg/kg. Soil gas probing holes will be sealed with grout (hydrated granular bentonite) following completion of sampling and analysis. An SOP for the field GC is contained in Appendix A.

5.2.4. Documentation

A field notebook will be kept for the soil gas survey. At a minimum, the field notebook will include project name and number, sample locations, dates and times, weather conditions, sampler's name, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site, limiting field conditions, and problems encountered. USEPA Region V acceptance of sampling locations will be noted in the field notebook. A report of analysis for total VOCs will be generated on a daily basis.

5.3. Waste sampling

5.3.1. Rationale/design

Four soil borings will be installed at Sites G, H, I, L, and N, and continuous soil samples will be collected from grade to 2 ft below the bottom of the fill material which is assumed to be 40 ft below grade (Figures 2 and 3). A discrete surface soil sample, from 0 to 0.5 ft, will also be collected at the location of the four soil borings at Sites G, H, I, L, and N. The surface soil samples analyzed will be used in the Human Health Risk Assessment (Volume 1B). Color digital photographs of each soil sample will be taken against a scale to provide a record of materials present in each fill area (Sites G, H, I, L, and N).

One composite waste sample will be collected at each boring location and analyzed for the waste disposal characteristics listed below. One discrete surface soil sample will be collected at each boring location and analyzed as listed below. Visual observation (discoloration) and PID readings will be used to identify whether waste is present in a continuous boring sample. If waste is present, it will be removed, segregated, temporarily stored, and used at the completion of the soil boring to prepare a composite waste sample. Since VOC samples can not be composited without losing volatiles, the waste sample with the highest PID readings will be used for VOC analysis. VOC samples will be collected using EnCore® samplers per USEPA Method 5035.

Experience at Sauget Area 2 Site R indicates that fill depth is unlikely to be greater than 40 ft. If wastes are encountered at depths greater than 40 ft below ground surface, borings will continue until the bottom of the fill is encountered.

Site M will be characterized by collecting four sediment samples at the preliminary locations shown on Figure 4.

Existing information (*e.g.*, the 1988 Ecology and Environment report and the results of the aerial photograph analysis, soil gas surveys, and magnetometer surveys conducted as part of the SSP) will be used to select boring locations.

Number of Waste Samples (composite boring sample): 24

Analyses:	Ignitability	USEPA Method 1010/1020A
	Corrosivity	USEPA Method 1110
	Reactivity	USEPA Method 9014
	TCLP	USEPA Method 1311
	VOCs	USEPA Method 5035/8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7471A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxins	USEPA Method 8280A

Number of Waste Samples (discrete surface sample): 20

Analyses:	VOCs	USEPA Method 5035/8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7471A

Cyanide	USEPA Method 9010B
PCBs	USEPA Method 680
Pesticides	USEPA Method 8081A
Herbicides	USEPA Method 8151A
Dioxins	USEPA Method 8280A

A 2-inch diameter well, screened at the bottom of the fill material, will be installed in the one waste characterization boring completed at Site G and one waste characterization boring completed at Site I to provide samples for leachate treatability testing.

Additional waste characterization borings may be required by USEPA Region V as a result of variability in waste characteristics observed during the waste characterization boring program.

Tables 2 and 3 are sample and analysis summaries for these activities.

5.3.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.3.3. Field procedures

Borings will be advanced using conventional hollow stem auger drilling methods using 4.25-inch inside diameter (ID) augers. Continuous 1.5-inch outside diameter (OD), 2-ft long split spoon samples will be collected from the

surface to the bottom of waste material. A discrete surface soil sample will be collected at each boring location prior to the completion of the boring activities. At each 10-ft interval of waste, a 3-inch OD split spoon sampler will be used to collect waste samples for laboratory analysis. Waste samples will be collected as presented below. Descriptive logs of each boring will be prepared as described below. A 2-inch OD stainless steel well will be installed in the borings of Sites G and I. The stainless steel wells will be installed following the procedures described below. Borings not used for the installation of sampling wells will be grouted to the surface to seal the borings. Boring equipment will be decontaminated as described below. Investigation derived waste will be disposed of as described below. A PID, explosimeter, and RAM will be used on a continuous basis to monitor the activities associated with waste sampling and well installation.

Waste sample collection. Waste samples will be collected using a 3-inch OD split spoon sampler. The split spoon sample will be obtained in accordance with ASTM Method 1586, with the exception of using a 3-inch OD split spoon. The following method will be used to collect waste samples.

1. Remove appropriate sample containers from the transport container, and prepare the sample containers for receiving samples. Sample containers will have a Teflon® septa.

2. Fill out a self-adhesive label with the appropriate information and affix it to the appropriate sample container. Place clear polyethylene tape over the completed label to protect it from dirt and water. Sample labels can be prepared prior to sample collection except for time and date. Labels can be filled in on the date of sample collection and just prior to collecting the sample. Sample containers will be kept cool with their caps on until they are ready to receive samples.

3. Place labeled sample containers near the sampling location.

4. Place clean plastic sheeting on the ground surface at the split spoon descriptive logging/sampling area

5. Put on a pair of nitrile gloves.

6. To collect a discrete waste sample for VOC analysis, a 5-gram EnCore® sampler will be used. After pressing the sampler into the soil at the desired location within the split spoon, cap the coring body while it is still in the EnCore® sampler T-handle. The remainder of the split spoon sample will be placed into a stainless steel bowl and homogenized. The remaining

sample containers will be filled from the steel bowl. For the discrete surface samples to be collected, the EnCore® sampler will be directly pushed into surface soils and handled as above.

7. Place the sample containers on ice in a cooler.

8. Begin chain-of-custody procedures. A sample chain-of-custody form is included as Appendix B.

9. Decontaminate the spoon/spatula and the steel bowl.

Logging unconsolidated samples. The geologist who logs samples is responsible to interpret the samples following standard and acceptable methods. The geologist who implements this work plan will have training and experience logging boring samples. Soil will be logged according to applicable ASTM standards. As appropriate, ASTM standards will be used to log waste materials.

At the outset of sample logging, the on-site geologist will record field notes with waterproof ink in a bound field notebook. At a minimum, the daily field notes will include:

- Project name and number
- Date and time
- Weather conditions
- Sampler's name
- Project objective(s).

Throughout the sampling round, the following items will be recorded as appropriate:

- Sample location(s)
- Sample identifications
- Well designations
- Limiting field conditions
- Problems encountered.

A copy of the test boring log to be used is included as Appendix C.

Unconsolidated soil samples will be described as follows:

- Descriptive information:
  - Color name, Munsell Color Chart, of the logged interval or sample
  - Color notation including chroma, hue, value, and qualifiers
  - Mottling with abbreviations, descriptors, and criteria for descriptions of mottles as identified below

Descriptors for mottling.

Abundance	Size	Contract
f: few (<2%)	fine (<5 mm)	faint
c: common (2%-20%)	medium (5-5mm)	distinct
m: many (>20%)	coarse (>15 mm)	prominent

- Degree of saturation (dry, damp, moist, wet, saturated, or combinations); note depth to ground water table, if observed.

- Degree of density. Count the blows of each 12-inch increment of the split spoon (ASTM-1586-84). Use the values in the table below to describe the density.

Terms to describe density.

Cohesive clays		Non-cohesive granular soils	
0-2	very soft	0-3	very loose
2-4	soft	4-9	loose
5-7	firm	10-29	medium dense
8-15	stiff	30-49	dense
16-29	hard	50-80	very dense
30-49	very hard	80+	extremely dense
50-80	extremely hard		

- Soil description according to ASTM's Unified Soil Classification System (USC) and by structure, according to the descriptions listed below:

  - ASTM Unified Soil Classification: Coarse-grained soils include clean gravels and sands and silty or clayey gravels and sands with more than 50% retained on the No. 200 sieve. The following table presents the grade limits and grade names used by engineers according to ASTM standards D422-63 and D643-78.

Grain size scale used by engineers.

Grade limits		Grade names		
mm	inch	US standard sieve series		
				boulders
305	12.0			
				cobbles
76.2	3.0	3.0 inch		
				gravel
4.75	0.19	No.4		
2.00	0.08	No. 10		
			medium	sand
0.425		No. 40		
0.074		No. 200		
				silt
0.005				
				clay size

Source: AGI data sheet 29.2

The following table shows the USC symbols and typical names of coarse-grained soils.

Coarse-grained soils: USCS symbols and typical names.

USCS symbol	Typical names
GW	Well graded gravels, gravel-sand mixtures, little or no fines
GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well graded sands, gravelly sands, little or no fines
SP	Poorly graded sands, gravelly sands, little or no fines
SM	Silty sand, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures

Fine-grained soils include inorganic and organic silts and clays; gravelly, sandy, or silty clays; and clayey silts with more than 50% passing the No. 200 sieve. The following table shows the USC symbols and typical names of fine-grained soils.

Fine-grained soils: USCS symbols and typical names.

USCS symbol	Typical names
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
CH	Inorganic clays of high plasticity (residual clays), fat clays
OH	Organic clays of medium to high plasticity, organic silts
Pt	Peat and other highly organic soils

Soil descriptors are as follows:

- **Calcareous**: containing appreciable quantities of calcium carbonate
- **Fissured**: containing shrinkage cracks, often filled with fine sand or silt, usually more or less vertical
- **Interbedded**: containing alternating layers of different soil types

- **Intermixed**: containing appreciable, random, and disoriented quantities of varying color, texture, or constituency
- **Laminated**: containing thin layers of varying color, texture, or constituency
- **Layer**: thickness greater than 3 inches
- **Mottled**: containing appreciable random speckles or pockets of varying color, texture, or constituency
- **Parting**: paper thin
- **Poorly graded (well sorted)**: primarily one grain size, or having a range of sizes with some intermediate size missing
- **Slickensided**: having inclined planes of weakness that are slick and glossy in appearance and often result in lower unconfined compression cohesion
- **Split graded**: containing two predominant grain sizes with intermediate sizes missing
- **Varved**: sanded or layered with silt or very fine sand (cyclic sedimentary couplet)
- **Well graded (poorly sorted)**: containing wide range of grain sizes and substantial amounts of all intermediate particle sizes
- **Modifiers**:
  - Predominant type - 50% to 100%
  - Modifying type - 12% to 50%
  - With - 5% to 12%
  - Trace - 1% to 5%

The table below presents the terms used to denote the various degrees of plasticity of soil that passes the No. 200 sieve.

Plasticity.

Descriptive term	Degree of plasticity	Plasticity index range
SILT	none	non-plastic
Clayey SILT	slight	1-5
SILT & CLAY	low	5-10
CLAY & SILT	medium	10-20
Silty CLAY	high	20-40
CLAY	very high	over 40

Items of information relating to drilling will be included on the log as follows:

- Drill rig manufacturer, model, and driller (if applicable)
- Geologist or geotechnical engineer
- Project name, sample point identification, and location
- Date samples obtained (and times if required)
- Type of sampler (for example, split spoon, Shelby, California), measurements or method of advancing boring or equipment, method of driving sampler, and weight of hammer.
- Drill fluids (if applicable)
- Ground surface or grade elevation (if known)
- Depth penetrated and blow counts/6-inch interval of penetration for ASTM 1586-84 and sample number (if applicable)
- Closed hole intervals and advancement (if applicable)
- Recovery
- Strata changes and changes within samples
- Sampling tool behavior
- Drill string behavior
- Use(s) of sample point or borehole
- Disposition(s) of residual soil or cuttings
- Signature or sampling of log (as required) .

Sampling point well installation. Sampling point monitoring wells will be constructed of a 5-ft section of 2-inch ID, manufactured wire-wound, 0.010-inch slotted stainless steel well screen and appropriate lengths of compatible 2-inch ID solid, threaded, flush-joint stainless steel riser. Following installation of the sampling wells, the tops of casing and ground surface will be surveyed to establish well and grade elevations and well locations. Well installation details will be documented on a test boring log (Appendix C) and

in the field notebook. The sampling point wells will generally be installed according to the typical well construction diagrams in Appendix D and as follows:

- Well materials will be inspected for proper specifications and integrity.
- The well screen, bottom cap, plug, and riser will be certified clean from the manufacturer. If they are not, they will be cleaned with a high-pressure steam cleaner.
- The total depth of the borehole will be measured referenced to existing grade and recorded. The quantities and lengths of all materials placed in the borehole will be measured and recorded. These materials include, but are not limited to: screen interval, blank casing or riser length, filter pack, bentonite seal, grout, and protective casing.
- The screen (with bottom cap) and riser assembly will be installed such that its midpoint approximately intersects the ground water table in the shallow ground water monitoring wells. The entire thickness of the intermediate aquifer will be screened. The well must be straight and vertical. Centralizers will be used as necessary to keep the monitoring well centered in the borehole.
- The filter pack will consist of an appropriately graded, washed silica sand, the thirtieth percentile grain size value of which must be four to ten times the equivalent thirtieth percentile grain size value of the stratum being monitored. The filter pack material will have a uniformity coefficient less than or equal to 2.5. The volume of filter pack necessary to fill the annular space will be computed and used to monitor the progress of installing the filter pack. The filter pack will be emplaced in increments to prevent bridging. If bridging occurs, the bridge will be broken before proceeding. The depth of the filter pack will be continuously checked with a weighted tape. The filter pack will extend a minimum of 2 ft above the top of the well screen.
- The augers or temporary casing will be withdrawn in no more than 5-ft increments to limit borehole collapse during emplacement of the filter pack. The lowest point of the casing or auger will not be more than 2 ft higher than the top of the filter material.

- A bentonite slurry seal will be tremied in place above the filter pack. The bentonite slurry seal will extend a minimum of 2 ft and not more than 3 ft above the top of the filter pack.

- A cement and bentonite grout mixture consisting of 5% bentonite by weight and Portland Type I cement will be tremied in place above the top of the bentonite slurry seal to 3 ft below existing grade. The grout mixture will be installed from the top of the bentonite seal upward to reduce the opportunity for the development of void spaces in the emplaced grout. The grout mixture must be pH neutral so as not to modify the pH of the ground water.

- A protective casing will be installed which extends from below the frost line to slightly above the top of the well casing. A weep hole will be drilled into the protective casing so accumulated water can drain.

- The concrete to be used to complete surface installation will be a commercially available, premixed cement, sand, and gravel mixture (*e.g.*, Quickrete).

Equipment decontamination. Decontamination of drilling and soil sample collection equipment will be performed prior to initiating drilling procedures, between boring locations, and at the completion of the drilling program prior to removal of equipment from the site. Drilling equipment and associated tools, including augers, drill rods, wrenches, auger shoes, split spoon samplers, and other equipment, that comes into contact with generated soils will be decontaminated by spray- washing with a high-pressure steam-cleaner. Prior to decontaminating the augers, as much soil as is practical will be removed and placed into the drum(s) associated with that particular boring location. A decontamination station will be set up by the drilling contractor such that decontamination fluids can be contained in drums. Decontamination solids will be placed with drummed soil cuttings. The split spoon sampler will be decontaminated with an Alconox soap wash, followed by a potable water rinse between sample collection at a particular location. The split spoon sampler will be decontaminated utilizing the high pressure steam cleaner between boring locations.

Disposal of investigation-derived wastes. During the subsurface investigation, subsurface soils, ground water, decontamination water, and general waste (plastic, paper, etc.) will be generated. Subsurface soils, ground water (development and purge water), and equipment decontamination water will be temporarily contained in drums and transferred to waste containers. General waste will be contained in plastic bags and disposed in a general

refuse container. If appropriate, a portion of the waste cuttings may be used for treatability test samples.

5.3.4. Documentation

A field notebook will be kept for the soil boring installation. At a minimum, the field notebook will include project name and number, date and time, weather conditions, sampler's name, sample location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other project personnel on-site. Notation of USEPA Region V acceptance of boring locations will be included in the field notebook.

5.4. Magnetometer survey

5.4.1. Rationale/design

Magnetometer surveys will be conducted at Sites G, H, I, L, and N to identify anomalies indicative of drum disposal or buried tanks. To evaluate whether the anomalies are associated with buried drums or tanks, test trenches will be dug at anomalies that coincide with ground water isoconcentrations greater than 10,000 ppb as identified by the 1998 Ecology and Environment Data Report, soil vapor extraction (SVE)anomalies detected during the soil gas survey, magnetic anomalies identified by the 1988 Ecology and Environment geophysical surveys, and areas of drum or tank disposal identified during historical aerial photo analysis of fill area boundaries. Magnetometer measurements will be made at locations determined by superimposing a 50 ft by 50 ft grid on the fill areas. Magnetometer measurement points will be located in the field by using known points such as buildings, roads, or other cultural features or by using GPS.

Site	Grid Size	Grid Spacing	Measurements
G	400' x 600'	50' x 50'	96
H	400' x 800'	50' x 50'	128
I	400' x 1,200'	50' x 50'	192
L	200' x 200'	50' x 50'	16
N	300' x 300'	50' x 50'	36
		Total number of measurements	468

Existing information on plume concentration, combined with information from the soil gas survey, will be used in evaluating whether magnetic anomalies indicate the presence buried drums or tanks. Fill areas in Sauget Area 1 were used for disposal of municipal and industrial waste as well as construction debris. Magnetic anomalies are likely to be numerous, intense, and wide spread in the fill areas. It is appropriate to use a screening method to identify those anomalies that should be excavated to evaluate if they are due to buried drums or tanks. Comparing ground water and soil gas concentration highs found at each fill area with corresponding magnetic anomalies at each fill area is a good method for selecting excavation locations within the fill areas, provided ground water and soil gas concentration highs have not migrated beyond the limits of the fill area. Coupling this information with prior geophysical surveys conducted by Ecology and Environment in 1988 and evaluation of historical aerial photograph analysis to identify portions of the fill areas where drums or tanks were placed will allow selection of test trenching locations that focus on areas where tanks or large numbers of drums may be buried. Reportably, the site may contain buried steel drums or debris to depths of 40 ft.

Surface geophysical surveys, which map the distribution of the strength of the earth's magnetic field, have been proven useful in evaluating shallow and deep subsurface conditions at environmental sites. These geophysical surveys have been used to successfully locate buried objects containing magnetically susceptible materials (*i.e.*, iron and nickel metals). The ability of geophysical equipment to locate buried objects is, for the most part, dependent on the strength and orientation of the magnetic anomaly associated with the buried objects, the strength and natural variation of the earth's magnetic field in response to local geology, and the influence of man-made surface features (such as power lines, buried utilities, vehicles, electric motors, etc.) which may interfere with the collection of data.

By comparing the known surface and geological conditions to a magnetic survey map that includes mapped surface feature interferences, and

understanding possible geologic background effects, it is possible to identify the location of suspicious subsurface features which may represent buried tanks or drum disposal areas.

Method. A geophysical survey of the site's magnetic field will be completed utilizing a total field magnetometer. The total field magnetometer measures the total strength of the site's magnetic field regardless of the orientation of the magnetic lines of force. The proposed field method involves the collection of magnetic data along pre-established profile lines. During the performance of the geophysical survey, data for the preparation of a field map will be collected. These data will include the total magnetic field strength at each data station, the location of physical site conditions (*i.e.*, streams, ditches, low areas, etc.), and the location of potential surface interferences (*i.e.*, vehicles, overhead power lines, etc.).

A correction for diurnal and micopulsation time variations is not necessary because the site and anticipated anomalies are relatively small in area (less than 1 sq mi), and subsurface anomalies from buried objects of interest should be relatively large (greater than 100 gammas).

A map showing the distribution of magnetic field strength over the five sites will be compiled and compared with the observed field conditions (including the location of known interfering objects such as vehicles, overhead power lines, and surface debris). By comparison, those magnetic anomalies which cannot be explained by observed site conditions will be presumed to be a result of buried subsurface material (*i.e.*, drums, tanks, metal debris, etc.). The depth of detection for suspect objects (such as steel drums) may vary according to orientation, method of manufacture and condition, and numbers present. Steel drums, such as those suspected to be present at this site, may be detected to depths of 40 ft.

Study area definition and measurement spacing. The area of the properties to be surveyed will be evaluated in the field. However, a general area for each survey area has been delineated and provided on a site plan (Figure 1). The study area consists of five site areas described above.

Overall site dimensions for the area will be adjusted based upon the findings of the source area boundary delineation activities discussed in section 5.1.

5.4.2. Field procedures

The following field equipment and procedures will be employed during this geophysical investigation.

Equipment. A Geometrics 858 Cesium or a Geometrics 856AX Total Field Magnetometer will be used to collect the field data. Field procedures and operation of the instruments will be in accordance with the recommended manufacturer's field procedure and application manual.

Calibrated field survey equipment consisting of marked survey line, tape rulers, highway danger cones, and marked wooden stakes will be utilized to establish measurement locations.

Preliminary testing and early termination procedures. The magnetometer has an internal startup test and check program which performs a diagnostic check of the battery and electronic circuitry. The unit will issue a warning statement if all components do not perform within the designed specifications. The magnetometer will not operate if the internal system check is out of compliance.

Instrument calibration and quality control procedures. The magnetometer will be calibrated to provide approximate value based on the established magnetic intensity for the region. The assumed magnetic field intensity for the site area is 51,000 gammas (based on the 1973 US Navy Map in: Applications Manual for Portable Magnetometers, Breiner, 1973). The calibration procedure is explained in the appropriate owner's operation manual and will vary between instrument models. The precise value for the intensity of the earth's magnetitic field at the site is not necessary to identify the location of buried drums.

Following the calibration of the instrument, a field check of the magnetometer readings will be conducted. Here, the instrument is held motionless and ten readings are recorded. Variations in the recorded value of + or - 1 gamma is acceptable. Adjustment in the height of the magnetometer sensor may be necessary to reduce the interference from surface debris; however, for the purpose of this investigation, a standard sensor height of 2 m will be assumed.

A continuous quality control program will be maintained by visually inspecting the data as they are acquired. The data are displayed in a digital format and an electronic beep is used to signal if data collection problems have resulted during the measurement. If a problem is detected, the measurement point will be recollected. The survey will not be continued until the data integrity has been assured.

Field progress/interpretation reporting. Progression of the geophysical survey will be documented in a field notebook. The beginning and ending time of each profile will be noted, and a field map of each completed profile will be maintained to field verify the progress of the survey.

Following the completion of the survey at each site, the magnetometer data will be downloaded twice to a laptop computer. Later, the two databases will be graphically compared to verify that the data download was complete and that the fidelity of the data transferred was protected.

Measurement point/grid surveying. The established survey lines will be marked in the field using a premarked survey line to maintain straight and precise station locations. Profiles will be completed along a straight line with an unobstructed line of sight. The corners of each of the grided areas will be marked with temporary corner stakes to permit the relocation of the measurement points within each site.

Data processing. Following completion of the field phase of investigation and verification that magnetometer data have been successfully transferred to the computer, the following data processing will be performed:

- A graphical review of data will be performed to compare the duplicate databases for completeness and fidelity.

- Cartesian coordinates corresponding to the map location of each measurement point will be assigned to the appropriate magnetometer reading.

- A map display of these data will be produced showing the location of the measurement points and the corresponding magnetometer reading. This map will be produced using AutoCAD Revision 14.

5.5. Buried drum and tank identification - test trenches

5.5.1. Rationale/design

If no excavation location criteria other than the presence of a magnetic anomaly is used to evaluate whether an excavation is appropriate, disturbance of a significant portion of each fill area is likely to result. Excessive trenching could result in unacceptable risks to the community, on-site workers, and the environment at sites that currently appear to be stable.

Test trenches to confirm the presence of buried drums or tanks will be conducted at Sites G, H, I, L, and N. Site G is a fill area stabilized by USEPA Region V in an emergency response that solidified organic wastes, placed a temporary soil cover the site, and controlled site access by installation of a fence. Recent inspection indicates the site is still stable. Site H is a grass field at the intersection of two major roads, Queeny Avenue and Falling Springs Road. It is across the street from the Cahokia Village Hall. Recent inspection indicates the site is stable with a vegetative cover and no wastes exposed at the surface. Commercial buildings and a self-storage facility are located on the site. Site L is located in a vegetated field and appears stable. Site N is located at the rear of a former construction company site that is now occupied by what appears to be a sign company, based on the large amount of sign installation and maintenance equipment parked in the parking along Falling Springs Road. The stability of Site N could not be assessed because it was not visible from publicly accessible areas. Evidence of site clearing across the entire parcel was readily discernible from Falling Springs Road.

Test trench locations will be identified using a combination of magnetic anomalies, aerial photograph analysis, and soil gas and ground water data. Test trenches will be conducted to evaluate the presence of buried drums or tanks at the sites. One test trench will be conducted at the largest magnetic anomaly found at each site that coincides with drum/tank disposal locations identified by historical aerial photograph analysis, an area of high VOC concentration in soil gas, an area of high ground water concentration identified in the 1998 Ecology and Environment Sauget Area 1 Data Report, or major magnetic anomalies report in the 1988 Ecology and Environment Report "Expanded Site Investigation, Dead Creek Project Sites at Cahokia/Sauget, Illinois". Care will be taken not to place major emphasis on the comparison of historical ground water concentrations and magnetic anomalies due to the extent of historical industrial ground water pumping in the area. Excavated soil and fill material will be returned to the test trench, with the exception of any intact drums, which will be removed provided confined space entry is not

needed to retrieve a drum. Trenches will not be entered to recover drums because of the danger inherent in such activities. Test trench locations will be determined using GPS and recorded for future reference in the event drum removal is appropriate. Recovered drums will be overpacked and stored pending disposal.

Free product and contaminated soil resulting from rupture of drums during removal will be cleaned up by absorbing any liquid materials and placing the absorbent, solid waste and contaminated soil in bulk containers at a controlled-access, fenced, investigation derived waste storage area to be constructed north of Judith Lane adjacent to Dead Creek. Overpacked drums will also be stored at this facility. Drum and waste storage may be indefinite if they contain materials that can not be accepted by off-site disposal facilities, e.g. dioxin. Any waste excavated that identifies the source of material present in the fill area will be noted in the field log and photographed.

Trenching to remove buried drums or tanks is an activity that should be done, if necessary, as part of a carefully planned removal action or when a remedy is implemented. Solutia is very concerned about the safety of workers, the community, and the environment during test trenching and drum removal activities. One release to the atmosphere, which sent five workers to the hospital, occurred during an investigation conducted in Creek Segment A. During World War II, the US government built and operated the Chemical Warfare Plant on 15 acres located in Monsanto's W.G. Krummrich plant. Solutia does not know what chemicals were produced by this facility. It is quite likely that raw materials, waste materials, and finished product from the US government's Chemical Warfare Service plant could be present in the fill areas located in Sauget Area 1. For this reason, Solutia believes intrusive activities at Sites G, H, and I to identify buried drums and tanks should be kept to an absolute minimum, if they are conducted at all. With the inherent danger to workers, the public, and the environment associated with drum removal activities, limited ground water downgradient migration of constituents at Sites G, H, and I and no downgradient ground water users, drum and tank removal during site investigation does not seem appropriate. If large numbers of intact drums are encountered and significant downgradient migration of constituents could occur if they were left in place until a remedy could be implemented, a carefully planned and executed removal action to stabilize the situation could be appropriate.

5.5.2. Field procedures

Anomaly test trench locations will be selected in the field based upon the parameters outlined in section 5.5.1 above, and with the concurrence of the USEPA Region V or its designee. To complete the anomaly test trenches, a track-mounted or wheel-mounted hoe will be utilized. As the depth to the top of buried anomalies is not anticipated to be up to 40 ft below grade, a smaller piece of equipment may be utilized for these anomaly test trenches compared to the trenches completed under section 5.1 to delineate the fill area boundaries for the sites. Trenching activities will be conducted in a manner to protect existing utilities, structures, surface features, monitoring wells, and the general site environment. Additionally, trenching activities will follow OSHA rules for excavations. A PID, an explosimeter, and a RAM will be used on a continuous basis to monitor the anomaly test trenches for hazardous conditions. The hoe operator will have a separate supplied-air system. Anomaly test trenches will be advanced until evidence as to the source of the anomaly is found or to a maximum depth of 40 ft, where possible. Should ground water infiltration and/or poor soil stability result in the inability to complete a test trench to 40 ft, the trenching will be terminated at that location. No accommodations will be made to dewater test trenches or manage ground water during excavation activities due to the need to minimize the generation of investigation-derived wastes.

As the trenching proceeds, spoils from the test trenches will be placed on polyethylene plastic having a minimum thickness of 6 mil. Provisions will be made to allow free liquids in the spoils to drain back to the trench. Spoils from each test trench will be segregated and returned to the excavation in reverse order of removal. Backfilling will be conducted in a manner to minimize ponding of water over the trench. A silt fence will be installed around the perimeter of the trench to minimize runoff of surface soils during rain events. If intact drums are found during anomaly test trench completion, they will be removed, over-packed, and stored in an area to be designated in accordance with the requirements of 29 CFR 1910.120(j). For planning purposes, it is anticipated that up to ten over-packs will be necessary per site and that one day of anomaly test trenching will occur at each of the five sites. A test trench at one location will be backfilled prior to the initiation of a test trench at another location. After completion of site investigation activities, the sites will be revegetated with grass. The silt fence will be maintained until revegetation is completed. Handling of investigation-derived wastes from these activities is discussed in Chapter 9.

5.5.3. Documentation

During anomaly trenching activities, a representative of O'Brien & Gere will complete a descriptive log for each anomaly test trench completed. At a minimum the following information will be included in the log:

- The date, time, weather conditions, equipment, and personnel on-site
- The total depth, length, and width of the anomaly test trench
- The depth and total thickness of distinct soil or lithologic units encountered
- A description of any waste excavated, as well as the identification of the source of the material, where possible
- PID, explosimeter, and RAM readings.

Additionally, the location of the anomaly test trenches will be laid out on a plan of the site. Digital photographs will be taken of the anomaly test trenches, the anomaly test trench walls, and any waste materials or drums excavated. The number and location of each photograph will be identified on the field log for each anomaly test trench.

5.6. Ground water sampling

Ground water samples will be collected in the alluvial aquifer and bedrock at the fill areas, in the alluvial aquifer downgradient of the fill areas, and in shallow ground water and domestic wells adjacent to Dead Creek. The purpose of this sampling is to define current ground water quality conditions at the source areas, to define the extent of migration away from the source areas, and to provide information for the human health risk assessment (construction/utility worker exposure, vapor intrusion into buildings, and residential use of ground water from shallow wells for lawn and garden watering). The Human Health Risk Assessment Work Plan is in Volume 1B.

5.6.1. Degree of hazard and mobility of COCs

Sample number, sample coordinates, and organic and inorganic constituents detected in ground water during past investigations of Sauget Area 1 will be compiled into a GIS-compatible data base, along with data from the EE/CA and RI/FS SSP. Frequency of detection, and average, maximum, minimum, and 95% confidence interval concentrations will be compiled for each detected constituent. Constituent mobility and hazard will be assessed during the human health risk assessment (Volume 1B Human Health Risk Assessment of the SSP).

5.6.2. Recharge and discharge areas

Ground water conditions in the American Bottoms have been studied extensively by the Illinois State Water Survey, Illinois State Geological Survey, and the U.S. Geological Survey. Information from these studies will be used to define recharge and discharge areas.

Experience at Site R and information from published reports on the American Bottoms aquifer indicate that ground water flow patterns in the study area are primarily controlled by the Mississippi River and, to a lesser degree, by Dead Creek. Both drainages run north/south, and ground water will flow toward them in an east/west direction. For ground water to flow from Sites G, H, I, and N to residences located south of these sites, a strong, local perturbation of the flow system would be needed, for example a high capacity pumping well. Plumes associated with Sites G, H, I, and L, as mapped by Ecology and Environment in 1998 (Appendix A of the SSP), do not indicate distortion of the plumes toward the residences on Walnut Street and Judith Lane. Intermittent pumping of domestic wells for gardening or lawn watering is unlikely to stress the aquifer enough to cause COCs to migrate 500 ft cross gradient. Evaluation of historical data, as described in section 5.6.3, will determine if high capacity industrial pumping occurred southwest of Site H.

To address USEPA Region V concern of a southwesterly flow direction from the source areas to the residential areas south of Judith Lane and west of Dead Creek, ground water samples will be collected at three locations on a transect running from Site G to Judith Lane.

5.6.3. Regional and local flow direction and quality

Ground water conditions in the American Bottoms have been studied extensively by the Illinois State Water Survey, Illinois State Geological Survey

and the U.S. Geological Survey. Information from these studies will be used to define regional and local flow direction and quality. Dead Creek data compiled by Ecology and Environment in 1998 will be integrated into this evaluation.

As directed by USEPA Region V, ground water flow conditions at the source areas will be evaluated by installing nine piezometer clusters at the locations shown on Figure 7. Each piezometer cluster will consist of three small-diameter wells completed in the shallow, intermediate, and deep portions of the alluvial aquifer. Water levels in each well will be measured quarterly for one year to define seasonal fluctuations in water level elevations. Water levels in existing wells will also be measured. Water level elevation maps will be prepared for each quarterly measurement round and included in the SSP Data Report.

5.6.4. Local uses of ground water

State, county, city, and village records will be searched to identify potential ground water users along Dead Creek. Domestic wells identified by Ecology and Environment are summarized below:

Owner	Street Address	Water Use	Depth
[redacted]	[redacted] Walnut Street	Greenhouse	17'
	[redacted] Falling Springs Road	Residential	20'
	[redacted] Judith Lane	Residential	---
	[redacted] Judith Lane	Residential	---
	[redacted] Judith Lane	Residential	49'
	[redacted] Judith Lane	Residential	---
	[redacted] Edwards Street	Residential	---
	[redacted] Cahokia Street	Residential	---
	[redacted] Cahokia Street	Residential	---

It is important to note that Cahokia and Sauget are served by a public water supply, and that these and other homes in the area are served by municipal water supply system.

5.6.5. Horizontal and vertical distribution of COCs

Ecology and Environment (1998) defined the areal extent of VOCs and SVOCs in shallow ground water at Sites G, H, I, and L. These plumes have migrated several hundred feet downgradient from disposal sites that were used from the 1930s to the 1970s. Plume shape indicates VOC and SVOC migration toward the Mississippi River, which is the discharge point for the American Bottoms aquifer. Ecology and Environment did not collect information on COC distribution in the intermediate and deep portions of the aquifer.

Aquifer saturated thickness in the study area is on the order of 80 to 100 ft, perhaps more. A vertical ground water sampling interval of 20 ft would result in four to five ground water samples per sampling station. A vertical sampling interval of 5 ft would result in sixteen to twenty samples per sampling station. Since the fill areas are 30 to more than 50 years old, the aquifer is thick, highly permeable, and homogeneous, and experience with similar hydrogeologic conditions indicates that leachate migration from these areas should produce plumes with a vertical dimension of more than 5 ft. Under these conditions, plumes are likely to have a vertical dimension of at least 20 ft thick, if not more. For this reason, a vertical sampling interval of 20 ft is considered appropriate. However, in order to address USEPA Region V concerns about adequate characterization of the plumes, vertical ground water samples will be collected every 10 ft.

5.7. Fill areas ground water sampling

5.7.1. Rationale/design

As directed by USEPA Region V in its March 19, 1999 comments on the SSP, ground water concentrations at the source areas will be evaluated by sampling existing Ecology and Environment wells (Appendix B of the SSP) EE-01, EE-02, EE-03, EE-04, EE-05, EE-12, EE-13, EE-14, EE-15, EE-20, EEG-101, EEG-102, EEG-103, EEG-104, EEG-105, EEG-106, EEG-107, EEG-108, EEG-109, EEG-110, EEG-111, and EEG-112. Each well will be located, checked for integrity of surface seals, checked for non-aqueous-phase liquid (NAPL), plumbed for depth and matched against construction records, redeveloped to remove accumulated fine-grained materials and promote ground water entry into the well and sampled to provide data on current ground water conditions at the source areas. If some or all of these wells no

longer exist or can not be sampled, ground water samples will be collected at the depth of the former screened interval using push sampling technologies such as Geoprobe™, HydroPunch™, MicroWell™, Waterloo Profiler™ or equivalent sampling technology and low-flow sampling techniques.

The location and purpose of sampling these wells are summarized below:

Site	Source Area or Downgradient Well	Shallow Ground Water Background Well	Screen Depth (ft below ground surface)
G	EE-05		18-23
	EEG-101		18-23
	EEG-102		16.5-21.5
	EEG-104		19-24
	EEG-106		18-23
	EEG-107		23-28
	EEG-112		21-26
H	EE-01		28-33
	EE-02		18-23
	EE-03		27-32
		EE-04	18-23
	EEG-110		18-23
I	EE-12		28-33
	EE-13		23-29
	EE-14		32.5-37.5
	EE-15		24-29
		EE-20	23-28
L	EEG-103		16.5-21.5
	EEG-105		No construction log
	EEG-109		17.5-22.55
South of G	EEG-111		No construction log
		EEG-108	24-29

Background ground water samples will be obtained from the middle and bottom of the aquifer at the location of existing wells EE-04, EE-20, and EEG-108 as described in section 5.16.

Number of Ground Water Samples 19

Analyses	VOCs	USEPA Method 8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8290

Sampling these wells provides more information that is needed to evaluate current conditions at the source areas or to provide information for the human health risk assessment. Collecting samples in the core of the plumes at Sites G, H, I, and L using existing wells EEG-107, EE-02, EE-16, and EEG-109 will provide adequate information for characterizing conditions at the source areas. If these wells do not exist, or are unusable, existing wells EEG-106, EE-01, EE-14, and EEG-103 could be used as alternative sampling locations at Sites G, H, I, and L, respectively.

Table 4 is a sample and analysis summary for this activity.

5.7.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.7.3. Field procedures

Ground water monitoring well redevelopment (if required). The objective of ground water monitoring well redevelopment is to clear the well of accumulated sediments, when 10% or more of the well screen has been occluded by sediment, so that representative ground water samples may be collected. The accumulated sediments need to be re-suspended in the water column in order to be removed. A variety of techniques can be used to re-suspend the sediments. Some of the common methods that can be used to re-suspend sediments include using a surge block, injection of air into the water column of the well, or using a bailer. Once the sediment is re-suspended, the water and sediment can then be removed from the well using a submersible pump, an air bladder pump, or a bailer. Redevelopment will be considered to be complete when the fine-grained materials have been removed.

For the existing ground water monitoring wells to be sampled for this project, the preferred method for redevelopment will be to use a surge block to re-suspend the sediments, and a submersible pump to remove the water and suspended sediments. However, if this method is ineffective, a combination of one or more of the methods indicated above will be used. The following procedures will be used when redeveloping an existing well.

- Place a clean, plastic drop cloth on the ground around the well to be redeveloped.
- Unlock the protective well cover and remove the well cap.
- Check the well for NAPL using an interface probe, as outlined in the water level measurement section below.
- Measure the depth to ground water and/or NAPL to the nearest hundredth of a foot.
- Measure the total depth of the well to the nearest hundredth of a foot. Note whether the bottom of the well feels hard or soft.
- Compare the total measured depth of the well to the record installed depth of the well, if available.

- If the comparison shows greater than 10% occlusion of the well screen, proceed with redevelopment. For wells that have no recorded installed depth and have a soft bottom, assume redevelopment will be required.

- Attach the decontaminated surge block to the appropriate lengths of pole section and push the surge block to the bottom of the well.

- Pull and push the surge block up and down to agitate the water and suspend the sediments in the well.

- Once sufficient re-suspension has occurred, pull the surge block out of the well.

- Attach an appropriate length of polyethylene tubing to a submersible pump, and lower the pump to near the bottom of the well, out of sediment that may be remaining in the bottom of the well.

- Place the discharge end of the tubing such that purged water will be collected in a 55-gal drum.

- Turn on the pump and adjust the flow rate to pump at a sufficiently high rate to allow the sediments to be removed without causing the pump to clog.

- Continue pumping until relatively sediment-free water is obtained.

- Remove the pump and allow the well to recover for half an hour. Re-measure the total well depth. If the measured depth indicates 10% or more occlusion, repeat steps 8 through 14. If the measured depth indicates less than 10% well screen occlusion, disconnect the tubing from the pump and place into the appropriate waste container. Dismantle the surge block and pole connectors for decontamination. Close and lock the protective casing. And, pick up and appropriately dispose of plastic sheeting and other disposables into the appropriate waste container. Close and properly label the 55-gal drum(s).

- Decontaminate the pump, wiring, and surge block system using the steam cleaner.

- Note in the field log book the approximate number of gallons of water removed during redevelopment of each well.

Pre-sampling procedures. As part of a sampling event, the following steps will initially be taken by personnel responsible for sampling:

- Obtain appropriate containers for sample collection. Containers will be provided by the laboratory performing the analyses.
- Examine sampler, containers, and preservatives; contact laboratory immediately if problems are found.
- Confirm sample delivery time and method of sample shipment with the laboratory.
- Assemble and inspect field equipment to be used for sample collection; verify that equipment is clean and in proper working order.
- Calibrate field instruments and/or meters to manufacturers' specifications. Conductivity, pH, and turbidity meters will be calibrated to known calibration standard solutions. Re-check calibration prior to the start of each day and after four hours of use. Calibration activities will be recorded on the ground water sampling log (Appendix E) and in the field notebook.
- Perform NAPL interface probe function test in accordance with section 6.1.11 of the Project QAPP.
- Establish well location and well identification.
- Obtain necessary keys for wells or gates.
- As feasible, begin sampling procedures at monitoring wells that are least impacted and proceed to those that historically have been impacted. A review of previous analytical data will be required prior to sampling.
- Examine each well for damage, tampering, erosion around the well casing, etc., and note on respective field log sheet.
- Place clean plastic sheeting around well to provide a barrier between the surrounding ground surface and sampling equipment used.
- Put on a new pair of disposable gloves.

- Open well cap and make a visual check down the casing and note the condition of the well casing and whether a permanent ground water level reference point has been established on the casing. Note on respective field log sheet.

- Perform ambient air monitoring for hazardous conditions on a continuous basis following opening of the well using a PID and an explosimeter. Record readings in the field notebook.

Water level measurements. Prior to initiating ground water sampling, water elevations will be measured in each of the wells on-site. Ground water level measurements will be collected as follows:

- A pre-cleaned, electric water level or NAPL interface probe will be used to measure the depth to water from the top-of-casing reference point and/or to check for NAPLs in the water column, where applicable. Record the depth of water and/or NAPLs, as applicable. This procedure will also be used to measure the depth of the well. Measurements will be made to the nearest 0.01 ft.

- After obtaining the water level, the volume of water within the well will be calculated.

- Decontaminate the water level and NAPL interface probe used in the well by thoroughly scrubbing with an Alconox® and potable water wash. Rinse with potable water, and then rinse twice with distilled water.

Record keeping. Prior to initiating the well purging process, the following information will be recorded in a field notebook and on the ground water sampling logs (Appendix E):

- Well number
- Day, date, and time
- Weather conditions
- Condition of the well and the surrounding area
- Sampling team members
- Instrument calibration information (before and after)
- Water level prior to purging
- Depth to the bottom of the well
- Volume of water to be purged
- Physical properties of evacuated water: color, odor, turbidity, presence of non-aqueous phase liquids

- Deviations from planned sampling methodology
- Ambient air monitoring readings.

Well purging. Prior to sampling, the wells will be purged to remove the standing water column from the well casing. A well volume of water is calculated using the following formula: $V = \pi r^2 h(7.48)$ where

V = Standing water volume in gallons to be purged

r^2 = inside radius of well in feet, squared

h = Linear feet of standing water in the casing.

One well volume will be calculated so field personnel know when to perform field measurements. Such measurements are performed after the removal of each well volume.

In ground water systems, naturally occurring metals tend to adsorb to the surfaces of solids. The level of adsorbance depends on the pH of the soil and water. The concentration of metals in dissolved form, therefore, is limited by this adsorption and by the metals' low solubility. Sediment in water is likely to have metal ions adsorbed to its particles, which analytical methods may not be able to differentiate from metal ions dissolved in the water. Ground water samples that contain sediment, therefore, may yield analytical results that do not represent the concentration of metals in the ground water itself.

Moreover, the transport of sediment is generally not due to the natural flow of ground water, but is induced by the sampling. Samples that are collected to be analyzed for metals should exhibit low turbidity, and they are generally filtered, therefore, to remove sediment. When possible, low turbidity samples should be obtained without filtering. Therefore, a low-flow peristaltic pump will be used at an appropriate flow rate of 100 ml/min for purging and to collect ground water samples. Should ground water depths exceed the suction head limitations of a peristaltic pump, a micro-bailer will be utilized for sample collection. A turbidity meter will be used to monitor turbidity during sampling. Following the extraction of each well volume, turbidity will be monitored in the field. Additionally, pH, conductivity, and temperature will be measured and recorded after each well volume removed. Samples will be collected when turbidity levels are below 5 nephelometric turbidity units

(NTU). Should a turbidity level of 5 NTU be unachievable after 2 hours of purging, the samples will be collected and the turbidity recorded.

The procedures for well purging are described as follows:

- Prepare the pump for operation. Follow the manufacturer's directions.
- Lower the pump to the screened zone of the well.
- Pump the ground water into a graduated pail. Continue pumping until the turbidity reading is at or below 5 NTU or the well is pumped dry. Lower the pump's intake as necessary.
- If the well is pumped dry, allow sufficient time for the well to recover before proceeding. Record this information on the ground water sampling log.
- In addition to the turbidity readings, in wells which exhibit sufficient recharge, also collect pH, conductivity, and temperature measurements. Three consecutive measurements should be within the following criteria:
  - ±0.25 units for pH
  - ±10% for specific conductivity
  - ±1 C° for temperature.

  Record this information on the ground water sampling log.
- Discharge the water removed during purging or possible decontamination procedures into 55-gal drums for disposal.

Sampling procedure. Each well will be sampled according to the following procedures:

- Remove the sample containers from their transport containers, and prepare the bottles for receiving samples. Inspect labels for proper sample identification. Sample containers will be kept cool with their caps on until they are ready to receive samples.
- The pump will be situated within the screened interval of the well so as to take into account past sampling activities and the fact that domestic well screens have been reported from 15 to 25 ft below ground surface. Should the water level in the well drop during pumping, the pump intake will be adjusted to maintain flow.

- Fill sample containers for VOC samples prior to filling other sample containers.

- Fill remaining sample containers.

- If the sample containers cannot be filled quickly, keep sample containers cool with the cap on until filled. Sample containers will be preserved as described in the QAPP.

- Return each sample container to its proper transport container. Preserve samples by reducing the temperature within the containers to approximately 4° Celsius using ice. Samples must not be allowed to freeze.

- Begin the chain-of-custody record.

- Record the physical appearance of the ground water observed during sampling on the ground water sampling log or in the field notebook.

- Replace the well cap and lock the well protection assembly before leaving the well location.

Sampling equipment decontamination.

- Brush-wash reusable sampling equipment in a bucket or tub using a trisodium phosphate (TSP), or other commercial detergent, solution (2 lb of TSP per 10 gal of clean water). Completely brush the entire exterior surface of the article undergoing decontamination. Wash interior wetted surfaces as required. Rinse the item with copious quantities of potable water, followed by a distilled water rinse.

- Rinse reusable sampling equipment used to collect environmental media for metals analysis in a dilute nitric acid solution, followed by a distilled water rinse.

- Air-dry sampling equipment on a clean, non-plastic surface in a well ventilated, uncontaminated environment. If the sampling device is not to be used immediately, wrap it in aluminum foil and place it in a plastic bag or storage container.

- Contain rinse waters in a plastic tub with a lid. Empty the contents of this tub daily into a 55-gal drum located at the investigation-derived waste storage area.

- Sample tubing will be disposed after each use, and new tubing will be used for each location.

Sample control and chain-of-custody.

- For proper identification in the field and proper tracking in the laboratory, samples will be labeled in a clear and consistent fashion, as outlined in section 6.1.2.

- Sample labels will be waterproof or sample containers will be sealed in plastic bags.

- Field personnel will maintain a sampling log sheet.

- The sampling log sheets will contain sufficient information to allow reconstruction of the sample collection and handling procedures at a later time.

- Each ground water monitoring well will have a corresponding sample log sheet which includes:

    - Sample identification number
    - Well location and number
    - Date and time
    - Sampler's name
    - Sample type (composite or grab)
    - Analysis for which sample was collected
    - Field parameters, including pH, temperature, and conductivity
    - Method of preservation
    - Additional comments as necessary.

- Each sample will have a corresponding entry on a chain-of-custody record. The record will include the items listed in section 6.1.3.

Following completion of the chain-of-custody record, the samples will be packaged for transport to the laboratory. A completed chain-of-custody document will be provided for each shipping container. The field sampler will make a copy of the chain-of-custody document to keep with the field notebook, and include the original chain-of-custody document in an air-tight plastic bag

in the sample cooler with the associated samples. Sample packaging and shipping procedures are described in Chapter 8.

Purge water. Purge water generated from ground water sampling activities will be contained in 55-gal drums and transported to the liquid waste disposal container.

Disposal of investigation-derived wastes. During the subsurface investigation, subsurface soils, ground water, decontamination water, and general waste (plastic, paper, etc.) will be generated. Subsurface soils, ground water (development and purge water), and equipment decontamination water will be temporarily contained in drums and transferred to waste containers. General waste will be contained in plastic bags and disposed in a general refuse container.

5.8. Alluvial aquifer ground water sampling

5.8.1. Rationale/design

As directed by USEPA Region V, one alluvial aquifer saturated-thickness sampling station will be located at the ground water concentration high at Site H and, one alluvial aquifer saturated-thickness sampling station will be located at the ground water concentration high at Site I (Figure 7). If available records or aerial photographs indicate the location of dredge spoil from Creek Segment A, the Site I alluvial aquifer saturated thickness sampling station will be placed at the location of this spoil instead of at the ground water concentration high, as directed by the USACE. Ground water samples will be collected at these locations in order to evaluate the vertical extent of organic and inorganic constituents migrating away from Sites H and I.

Telescoping surface casing will be installed to depths of 5 ft and 20 ft below the fill material in order to minimize carry-down of site-related constituents during ground water sample collection. This casing will be grouted from the bottom up after completion of sampling.

Ground water samples will be collected every 10 ft from bottom of the surface casing to bedrock, which are assumed to be 60 and 100 ft deep, respectively, using push sampling technologies such as Geoprobe™, HydroPunch™, MicroWell™, Waterloo Profiler™, or equivalent sampling technology and low-flow sampling techniques.

Number of Ground Water Samples 8

Analyses	VOCs	USEPA Method 8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8290

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 5 is a sample and analysis summary for this activity.

5.8.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.8.3. Field procedures

Field procedures for collection of alluvial aquifer ground water samples will follow procedures for collection of ground water in the fill areas as described in section 5.7.3.

5.9. Downgradient alluvial aquifer sampling

5.9.1. Rationale/design

Sites G, H, and L. The horizontal and vertical extent of organic and inorganic constituents migrating away from Sites G, H, and L and toward the Mississippi River will be evaluated by collecting samples at three sampling stations located along a transect between the maximum shallow ground water concentrations at Site G and Illinois Route 3 (Figure 7). Ground water samples will be collected every 10 ft from the water table to bedrock, which is assumed to be 100 ft deep, using push sampling technologies such as Geoprobe™, HydroPunch™, MicroWell™, Waterloo Profiler™, or equivalent sampling technology and low-flow sampling techniques.

Experience at other sites indicates that push sampling technologies such as Geoprobe™ can reach depths of 60 ft. Depth of penetration can be increased at some locations by loosening the soil above the sampling horizon with a small-diameter solid stem auger before pushing the sampling probe to the required sampling depth. When the Geoprobe™ sampler or equivalent sampling technology can not penetrate to the required sampling depth, MicroWells™ will be used to collect ground water samples. These small-diameter wells are vibrated into place using a small vibratory hammer. Experience in deep aquifers at other sites indicates that sampling depths of 100 ft can be achieved. If the required sampling depths can not be reached with either of these two technologies, conventional percussion drilling equipment will be used to drive 1-1/4 inch diameter drive points to the required sampling depths.

Number of Ground Water Samples 30

Analyses	VOCs	USEPA Method 8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Site I. The horizontal and vertical extent of organic and inorganic constituents migrating away from Site I and toward the Mississippi River will be evaluated by collecting samples at three sampling stations located along a transect between the maximum shallow ground water concentrations at Site I and Illinois Route 3 (Figure 7). Ground water samples will be collected every 10 ft from the water table to bedrock, which is assumed to be 100 ft deep, using push sampling technologies such as Geoprobe™, HydroPunch™, MicroWell™, Waterloo Profiler™, or equivalent sampling technology and low-flow sampling techniques.

Number of Ground Water Samples 30

Analyses	VOCs	USEPA Method 8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Areas southwest of Sites G, H, I, and L. The horizontal and vertical extent of organic and inorganic constituents migrating away from Sites G, H, I, and L and moving in a southwesterly direction will be evaluated by collecting samples at three sampling stations located along a transect between the maximum shallow ground water concentrations in Site G and Illinois Route 3

(Figure 7). Ground water samples will be collected every 10 ft from the water table to bedrock, which is assumed to be 100 ft deep, using push sampling technologies such as Geoprobe™, HydroPunch™, MicroWell™, Waterloo Profiler™, or equivalent sampling technology and low-flow sampling techniques.

Number of Ground Water Samples 30

Analyses	VOCs	USEPA Method 8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Dioxin sampling. Presence or absence of dioxin in ground water migrating away from Sites G, H, I, and L will be evaluated by analyzing samples from the shallow (20 ft below ground surface), intermediate (60 ft below ground surface), and deep (100 ft below ground surface) portions of the alluvial aquifer at each of the three sampling stations downgradient of Sites G, H, and L; each of the three sampling stations downgradient of Site I; and each of the three sampling stations southwest of Sites G, H, I, and L. Samples will be collected concurrently with the VOC, SVOC, metals, mercury, cyanide, PCB, pesticide, and herbicide samples described above.

Number of Ground Water Samples 27

Analyses Dioxin USEPA Method 8290

Table 6 is a sample and analysis summary for this activity.

5.9.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.9.3. Field procedures

Push point. Using the hydraulic push system of a Geoprobe™, or similar unit, a mill-slotted or stainless steel screen point will be pushed to the water table. A high-density polyethylene (HDPE) (or Teflon®-lined or Teflon®) tube will be inserted into the center annular space to approximately one to one and one-half feet above the bottom of the screen. An appropriate length section of flexible fluoropolymer tubing will be attached to the HDPE tubing using a barbed connector. The flexible tubing will be connected through the head of the peristaltic pump. The open end of the flexible tubing will be located so it can discharge into a purge water container (5-gal bucket). The peristaltic pump will be turned on at an approximate flowrate of 100 ml/min. The purging will continue for 60 minutes. As the 5-gal discharge bucket fills, it will be replaced with an empty bucket, and the full bucket will be emptied into a 55-gal drum. At the end of 60 minutes, the pH, conductivity, temperature, and turbidity will be measured and recorded in the field sampling notebook. If the turbidity is greater than 5 NTU, purging will continue. Once the turbidity is at or below 5 NTU or 2 hours have elapsed, ground water samples will be collected into labeled, pre-preserved (where necessary), laboratory-provided containers. Sample containers for VOC analysis will be filled first. Collected samples will be placed on ice in a cooler, and chain-of-custody procedures will be initiated. The fluoropolymer tubing will be disconnected from the peristaltic pump. The HDPE tubing will be pulled from the center annular space. The flexible tubing and HDPE tubing will then be discarded into plastic trash bags. Clean sections of push rods will be connected, the sampling point will be advanced 10 ft, and the sample collection method will be repeated.

MicroWell™. It is anticipated the above sampling method will be used as feasible. However, based on the location of the site within the Mississippi River flood plain, large gravel or cobbles may be encountered which will stop the Geoprobe™. Should this occur, MicroWells™ would be installed to use as the sample collection point. The MicroWells™ will be hydraulically pushed to the appropriate depth, and the sampling procedure described above, beginning with inserting the tubing through the annular space, will be followed. Once the sample is collected, the MicroWell™ will be pulled, the screen point decontaminated according to the method described below, and a new well will be advanced 10 ft further in the same hole. This procedure will be repeated until reaching bedrock.

Should MicroWell™ installation prove impractical, boreholes will be advanced using conventional hollow stem auger drilling methods. In this instance, the lead auger will have a screened section through which ground water will flow. A submersible Grundfos Rediflow™ pump will be placed through the center of the augers to approximately two feet from the bottom. The pump will have the appropriate length of HDPE tubing attached. The tubing will discharge to the 5-gal bucket at before. The sample will be collected from the tubing, filling the VOC containers first. Once all the samples are collected, the augers will be advanced 10 ft; a new, clean section of tubing will be attached to the pump; and additional samples will be collected. This procedure will be repeated to bedrock. All Geoprobe™, MicroWell™, or Waterloo Profiler™ holes or casings will be sealed with grout from the bottom up after completion of sampling at each location. A PID, an explosimeter, and a RAM will be used on a continuous basis to monitor these activities.

Sampling equipment decontamination.

- Brush-wash reusable sampling equipment in a bucket or tub using a trisodium phosphate (TSP), or other commercial detergent, solution (2 lb of TSP per 10 gal of clean water). Completely brush the entire exterior surface of the article undergoing decontamination. Wash interior wetted surfaces as required. Rinse the item with copious quantities of potable water, followed by a distilled water rinse.

- Rinse reusable sampling equipment used to collect environmental media for metals analysis in a dilute nitric acid solution, followed by a distilled water rinse.

- Air-dry sampling equipment on a clean, non-plastic surface in a well ventilated, uncontaminated environment. If the sampling device is not to be used immediately, wrap it in aluminum foil and place it in a plastic bag or storage container.

- Contain rinse waters in a plastic tub with a lid. Empty the contents of this tub daily into a 55-gal drum located at the investigation-derived waste storage area.

5.9.4. Documentation

A field notebook will be kept for the alluvial aquifer sampling. At a minimum, the notebook will include project name and number; date and time; weather conditions; sampler's name; sample location, pH, conductivity, temperature, PID, explosimeter, RAM, and turbidity measurements; changes in sampling technique; depths of sample collection; limiting field conditions; problems encountered; subcontractor personnel on-site; USEPA Region V personnel on-site; and other personnel on-site. Notation of USEPA Region V acceptance of sampling locations will also be included in the field notebook.

5.10. Bedrock ground water sampling

5.10.1. Rationale/design

As directed by USEPA Region V, three bedrock wells will be installed in the middle of Sites G, H, and I in order to evaluate the vertical extent of organic and inorganic constituents migrating away from these sites. Telescoping surface casing will be installed to depths of 5 ft and 20 ft below the fill material and 5 ft into bedrock in order to minimize carry-down of site-related constituents during ground water sample collection and vertical migration of site-related constituents after completion of sampling.

Bedrock will be cored to a depth of 20 ft below the telescoping casing. Cores will be digitally photographed in color against a scale and evaluated for porosity by examination and petrographic thin sections. A ground water sample will be collected from each core hole.

Sampling locations will be based on the fill area shallow ground water sampling results (section 5.7.1).

Number of Ground Water Samples 3

Analyses	VOCs	USEPA Method 8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8290

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 7 is a sample and analysis summary of this activity.

5.10.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.10.3. Field procedures

Mud rotary drilling methods will be used to drill the boreholes to set the telescoping casing and to drill 5 ft into the top of bedrock. Coring will then be accomplished using wireline coring barrels to generate a 2-inch minimum core. Coring will continue for 20 ft into the bedrock. Core samples will be photographed and described on test boring logs. Descriptions will follow the procedures outlined below. After coring is completed, a ground water sample will be collected from the bedrock core hole. Sampling will be accomplished using a Grundfos Rediflow™ pump, control box, and electrical generator. Sampling will be accomplished following applicable procedures outlined in section 5.7.3. A PID, an explosimeter, and a RAM will be used on a continuous basis to monitor these activities.

Once sample collection is completed, the pump and tubing will be pulled. The tubing will be placed into a plastic trash bag and disposed of in the general waste dumpster. The bore hole will be abandoned by filling the annular space with a cement and bentonite grout from bottom to top. The surface top 2 ft will be restored with soil and seeded. The drill rig will be moved to the decontamination station and steam cleaned. Solids will be placed into a container for transport to the soils disposal collection container.

Sampling equipment decontamination.

- Brush-wash reusable sampling equipment in a bucket or tub using a trisodium phosphate (TSP), or other commercial detergent, solution (2 lb of TSP per 10 gal of clean water). Completely brush the entire exterior surface of the article undergoing decontamination. Wash interior wetted surfaces as required. Rinse the item with copious quantities of potable water, followed by a distilled water rinse.

- Rinse reusable sampling equipment used to collect environmental media for metals analysis in a dilute nitric acid solution, followed by a distilled water rinse.

- Air-dry sampling equipment on a clean, non-plastic surface in a well ventilated, uncontaminated environment. If the sampling device is not to be used immediately, wrap it in aluminum foil and place it in a plastic bag or storage container.

- Contain rinse waters in a plastic tub with a lid. Empty the contents of this tub daily into a 55-gal drum located at the investigation-derived waste storage area.

Decontamination water will be placed into a temporary container and transported to the wastewater disposal container. Investigation-derived wastes, such as disposable gloves, paper towels, plastic sheeting, and Tyvek™ suits (if worn), will be containerized and taken to the general refuse container for disposal.

Method. The geologists and geotechnical engineers will write their description of rock samples with a consistent format. The order and presentation of selection of data are presented below.

The order in which the rock description is to be documented must be observed. Follow the order presented below.

Order of description for lithology.

1. color	9. weathering
2. rock quality	10. surface
3. porosity	11. hardness
4. beds	12. texture
5. thickness	13. grain shape
6. contact	14. sorting
7. foliation	15. mineral components
8. joints	16. rock classification

Abbreviations of the descriptions will conform to the standard abbreviation list. This list is presented below. A word that is not on this list will be spelled out. An initial capital letter will be used for each rock type. Capital letters will be for formation names and rock types.

Punctuation will also be standardized. The following convention will be used for punctuation:

- Comma after each item of description
- Semi-colon between each rock-type description
- No full stops (periods).

In addition, remarks such as *A/A* ("as above"), *same as above, see above,* or *same* are undesirable.

Log order of presentation and selection. The following order will be used to present information on the log:

1. Color
Color (from Munsell Color Chart) of logged interval or mass (sample).

2. Rock quality
The rock quality designation (%RQD) is computed in the following way:

%RQD = 100 x [length of core in pieces ≥4'] +
[hole length drilled or attempted (cored)]

Guidelines:

- Measure from the center of natural breaks.
- Exclude joints that dip within 5 degree of core axis.
- Exclude drill breaks. (See criteria for identification of drill breaks.)
- Do not calculate RQD for soft semi-indurate rock or severely weathered rock ("Weathering" is addressed below.)

Scale:

90 - 100	excellent.....massive
75 - 90	good.....lightly fractured
50 - 75	fair.....moderately fractured
25 - 50	poor.....highly fractured
0 - 25	very poor.....sheared

It is appropriate to think of RQD in conditions of equal effect; that is, group the RQD ranges as equivalent to rock type, structural domain, shear zones, and so forth.

Criteria for identifying drilling breaks

- A rough, brittle surface with fresh cleavage planes in individual rock minerals indicates an artificial fracture.

- A generally smooth or somewhat weathered surface with soft coating or infilling materials such as talc, gypsum, chlorite, mica or calcite obviously indicates a natural discontinuity.

- In rocks showing foliation, cleavage, or bedding, it may be difficult to distinguish between natural discontinuities and artificial fractures when these are parallel with the incipient planes of weakness. If drilling has been carried out carefully, then the questionable breaks should be counted as natural features, to make the conservative assumption.

- Depending on the drilling equipment, part of the length of core being drilled may occasionally rotate with the inner barrels in such a way that grinding of the surfaces of discontinuities and fractures occurs. In weak rock types, it may be difficult to decide if the resulting rounded surfaces are present natural or artificial features. When in doubt, the conservative assumption should be made; that is, assume that they are natural.

- It is appropriate to keep a separate record of the frequency of artificial fractures for assessing the possible influence of blasting on the weaker sedimentary and foliated or schistose metamorphic rocks.

The occurrence of impurities is qualified with the following terms:

consolidated, unconsolidated, semi-consolidated round, sub-round, sub-angular, angular, ellipsoidal, spherical.

masses	brecciated	trace remnants
pockets	chaotically intermixed	disseminated throughout matrix
nodules	fine wispy layers	scattered
blebs	stringers	streaks or specks
lenses	subtle network	narrow zones
oolites	chicken wire pattern	
zones	dendritic	
transitions		

3. Porosity

Use the following descriptions: none, medium, moderate, very, pinhole porosity, visual porosity.

4. Beds
Bedding, horizontal or inclined:

planar
mylonitic
folded
contorted
wavy banding

Bedding, beds, cleavage, and foliation:

very thin	1-3 cm (0.4-1")
thin	3-10 cm (1-4")
medium	10-30 cm (4"-1')
thick	30-100 cm (1'-3')
very thick	> 100 cm (>3')

Lamina
laminated: 0.3-1 cm (0.4-0.1")
thinly laminated: <0.3 cm (<0.4")

5. Thickness, laminations, lamella, seams
smooth
broken
irregular
convoluted
up/down criteria

6. Contact
distinct
vague
gradational

7. Foliation
fissile (planar splitting)
non-fissile

8. Joints

planar parting planes	irregular break scalloped conchoidal	infilled with healed fracture mylonitic

Spacing

very thin	1-3 cm (0.4-1")
thin	3-10 cm (1-4")
medium	10-30 cm (4"-1")
thick	30-100 cm (1'-3')
very thick	> 100 cm (>3')

9. Weathering

Fresh Rock fresh; crystals or grains bright; a few joints may show slight staining; crystalline rocks ring if struck with a hammer.

Slight Rock generally fresh; joints stained and may show clay filling if open; staining may extend into rock fabric adjacent to weathered planes; if present, feldspars may be dull and discolored; crystalline rocks ring if struck with hammer.

Moderate Except for quartz, most of the rock mass shows discoloration and weathering; most feldspar is dull and discolored and kaolinitization (alteration to clay minerals) is common; rock gives a dull sound if struck with hammer; rock shows overall loss of strength; potions may be removed with a geologist's pick.

Severe All minerals except quartz discolored or stained; rock fabric still discernible; intergranular or intercrystalline disassociation virtually complete; internal structure essentially that of soil; fragments of strong rock may remain; may be called saprolite.

Complete Rock is decomposed to a soil; fabric not discernible or only barely discernible; quartz may remain as dikes or stringers.

10. Surface

Solid Contains no voids.

Pitted Small voids generally restricted to joint surfaces, bedding planes, or other surfaces which provide access for attacking fluids.

Vuggy Use restricted to solution voids in carbonate rocks and hydrothermally altered rocks; voids may be found throughout the rock face; voids up to 9 inch diameter.

Vesicular Use restricted to voids in igneous (occasionally metamorphic) rocks, void origin usually due to gas bubbles; voids up to 3 inch average diameter.

Cavernous Applicable in any rock; voids and channels greater than 9 inch average diameter; voids large enough to cause serious leakage or structural problems.

11. Hardness

The following scale (not to be confused with Moh's scale for hardness of minerals) is used to a rock:

Very hard Cannot be scratched with knife or sharp pick; breaking of hand specimens require several hard blows of geologist's pick.

Hard Can be scratched with knife or pick only with difficulty; hard blow of hammer required to detach hand specimen.

Moderately Can be scratched with knife or pick; gouges or groves to 1/8 inch deep can be excavated by hard blow of point of geologist's pick; hand specimens can be detached by moderate blow.

Medium Can be grooved or gouged 1/16 inch deep by firm pressure on knife or pick point; can be excavated in small chips to pieces about 1 inch maximum size by hard blows of the point of a geologist's pick.

Soft Can be gouged or grooved readily with knife or pick point; can be excavated in chips to pieces several inches in size by moderate blows of a pick point; small thin pieces can be broken by finger pressure.

Very soft Can be carved with knife; can be excavated readily with point of pick; pieces 1 inch or more in thickness can be broken by finger pressure; can be scratched readily by fingernail.

12. Texture
American Geological Institute data sheets

fine = <1 mm
medium = 1.5 mm
coarse = >5 mm

13. Grain shape
very angular
angular
subangular
subrounded
rounded
well rounded

14. Sorting (for sedimentary rocks)
very well sorted
well sorted (poorly graded)
moderately sorted
poorly sorted (well graded)
very poorly sorted

15. Mineral components

16. Rock classification
American Geological Institute data sheets.

Accepted abbreviations.

A

about ..... ABT
above ..... ABV
abundant ..... ABDT
accumulation ... ACCUM
acicular ..... ACIC
aggregate ..... AGG
agglomerate ..... AGLM
algae ..... ALG
altered ..... ALT
amorphous ..... AMOR
amount ..... AMT
angular ..... ANG
anhedral ..... ANHED
anhydrite ..... ANHY
anhydritic ... ANHYDRIC

apparent ..... APR
appears ..... APRS
approximate .... APROX
aragonite ..... ARAG
arenaceous ..... AREN
argillaceous ..... ARG
arkose ..... ARK
asphalt ..... ASPH
at ..... @
average ..... AV

B

band ..... BND
banded ..... BNDD
barite ..... BAR
basalt ..... BAS
bed ..... BED
bedded ..... BEDD
bedding ..... BEDG
bentonite ..... BENT
biotite ..... BIOT
bitumen ..... BIT
black ..... BLK
bleeding ..... BLDG
blocky ..... BLKY
botryoida ..... BTRI
bottom ..... BTM
boulder ..... BLDR
brachiopod ..... BRAC
breccia ..... BREC
brittle ..... BRIT
bright ..... BRI
broken ..... BRKN
brown ..... BRN
bryozoa ..... BRY

C

calcite ..... CA
calcareous ..... CALC
carbonaceous .... CARB
cavernous ..... CAV
caving ..... CVG
cement ..... CMT
center ..... CNTR
cephalopod ..... CEPH
chalcedony ..... CHAL
chalk ..... CHK
chert ..... CHT
chitin ..... CHIT
chlorite ..... CHL
chloritic ..... CHLTC
clastic ..... CLAS
clay ..... CLY
claystone ..... CLYST
clean ..... CLN
clear ..... CLR
cleavage CLV
cluster ..... CLS
coal ..... COAL
coarse C
cobble ..... CBL
color ..... COL
common ..... COM
compact ..... COMP
conchoidal ..... CONCH
concentric ..... CNCN
conodont ..... CONO
conglomerate ..... CGL
contact ..... CONT
contorted ..... CONTRT
coquina ..... COQ
covered ..... COV
cream ..... CRM
crenelated ..... CREN
crevice ..... CREV
crinkled ..... CRNK
crinoid ..... CRIN
crossbedded .... XBEDD
crosslaminated .... XLAM
cross-stratified .. XSTRAT
cryptocrystalline CRPXLN
cryptograined ... CRPGR
crystal XL
crystalline ..... XLN
cuttings ..... CTGS

D

dark ..... DK
dead ..... DD
debris ..... DEB
degree ..... DEGR
dendritic ..... DEND
dense ..... DNS
determine ..... DTRM
detrital ..... DTRL
diameter ..... DIAM
diatoms ..... DIAT
difference ..... DIF
disseminated ..... DISM
dolocast ..... DOLC
dolomite ..... DOL
dolomitic ..... DOLIC
dolomoid ..... DOLM
drusey ..... DRSY

E

earthy ..... ETHY
echinoid ..... ECH
eliptical ..... ELIP
elongate ..... ELNG

embedded .... EMBEDD
enlarged ..... ENL
epidote ..... EP
equivalent ..... EQUIV
euhedral ..... EUHED
evaporitic ..... EVAP
expose ..... EXP
extrusive ..... EXTRU

F
faceted ..... FAC
faint ..... FNT
fair ..... R
fault ..... FLT
fauna ..... FAU
feldspar ..... FELS
ferruginous ..... FE
fibrous ..... FIB
figured ..... FIG
fine,-ly ..... F
fissile ..... FISS
flaggy ..... FLGY
flake,-y ..... FLK,-Y
flinty ..... FLTY
floating ..... FLTG
fluorescence ..... FLUOR
foliated, -ion ..... FOL
foraminifera .... FORAM
formation ..... FMTN
fossil ..... FOSS
fossiliferous ..... FOSSIF
fracture,-ed ..... FRAC
fragment ..... FRAG
fresh ..... FRSH
friable ..... FRI
frosted ..... FROS
fusilinid ..... FUS

G
gabro ..... GAB
gastropod ..... GAST
glassy ..... GL
glauconite ..... GLAUC
globular ..... GLOB
gloss ..... GLOS
gneiss ..... GN
good ..... G
grade ..... GRD
grading ..... GRDG
grain ..... GRN
granite ..... GRNT
granular ..... GRAN
granule ..... GRNL
graptolite ..... GRAP
gravel ..... GVL
gray ..... GRY
graywacke ..... GYWKE
greasy ..... GRSY
green ..... GREEN
gritty ..... GRTY
gypsum ..... GYP
gypsiferous ..... GYPS

H
hard ..... HD
heavy ..... HVY
hematite ..... HEM
high ..... HI
horizontal ..... HOR
hornblende HBD
hydrocarbon ..... HYDC

I
igneous ..... IG
imbedded ..... IMBEDD
impregnated ..... IMPRG
impressions ..... IMP
included ..... INCL
inclusion ..... INCLSN
increase ..... INCR
indistinct ..... IND
interbedded ... INTBEDD
intercrystalline ... INTXLN
intergranular ... INTGRAN
intergrown .... INTGWN
interlaminated ... INTLAM
interstitial ..... INTSTL
interval ..... INTVL
intraformational ... INTRM
intrusion ..... INTR
invetebrate ..... INVRTB
iron ..... FE
iron Oxides ..... FE-OX
ironstone ..... FE-ST
irregular ..... IREG
iridescent ..... IRID

J
jasper ..... JASP
jointed ..... JTD

jointing ..... JTG
joints ..... JTS

K
kaolin,-ite ..... KAOL

L
laminated ..... LAM
large ..... LRG
lavender ..... LAV
layer ..... LYR
leached ..... LCHD
ledge ..... LDG
lenticular ..... LENT
light ..... LT
lignite ..... LIG
limestone ..... LS
limonite ..... LMNT
limy ..... LMY
lithic ..... LITH
lithographic ..... LITHG
little ..... LTL
long ..... LONG
l ..... OOSELSE
lower ..... LOW
lumpy ..... LMPY
luster ..... LSTR

M
macro-fossil ... MACFOS
magnetic ..... MAGN
magnetite ..... MAG
marl ..... ML
marlstone ..... MRLST
maroon ..... MAR
massive ..... MASS
material ..... MAT
matrix ..... MTX
maximum ..... MAX
medium ..... M
member ..... MBR
metamorphic ... METAM
mica ..... MIC
micaceous ..... MICAC
microcrystalline .. MICXLN
microfossil ..... MICFOS
micrograined .... MICGR
micromicaceous ... MMIC
middle ..... MID
mineral ..... MNRL
minimum ..... MIN
minor ..... MNR
minute ..... MNUT
moderate ..... MOD
mollusca ..... MOL
mottled ..... MOT
mudstone ..... MDST
muscovite ..... MUSC

N
nacreous ..... NAC
nodule ..... NOD
numerous ..... NUM

O
object ..... OBJ
occasional ..... OCC
ocher ..... OCH
odor ..... ODOR
..... oil
..... OIL
olive ..... OLV
oolitic ..... OOL
opaque ..... OPG
opposite ..... OPP
orange ..... ORNG
organic ..... ORG
orthoclase ..... ORTH
ostracod ..... OST
oxidized ..... OX

P
patchy ..... PCHY
part ..... PT
parting ..... PTG
pearl ..... PRL
pebble ..... PBL
pegmatite ..... PEG
pelecypod ..... PLCY
pellet ..... PEL
permeability ..... PERM
petroleum ..... PET
phosphate ..... PHOS
pink ..... PNK
pinpoint porosity .... PPP
pisolite ..... PISO
pitted ..... PIT
plagioclase ..... PLAG
plant fossils ..... PL FOS
plastic ..... PLAS
platy ..... PLTY
polish ..... POL
poor ..... PR
porcelaneous ..... PORC
porosity ..... POR
porphyry ..... PORPH
possible ..... POS
predominant ..... PRED
preserved ..... PRES
primary ..... PRIM

prismatic ..... PRIS
probably ..... PROB
prominent ..... PROM
pseudo ..... PSDO
purple ..... PURP
pyrite ..... PYR
pyrobitumen .... PYRBIT
pyroclastic ... PYRCLAS

Q
quartz ..... QTZ
quartzite ..... QTZT
quartzitic ..... QTZTC
quartzose ..... QTZS

R
radiate ..... RAD
range ..... RNG
random ..... RAND
rare ..... RR
red ..... R
regular ..... REG
remains ..... RMN
replaced ..... RPL
residue ..... RESD
resinous ..... RSNS
rhombohedral ... RHMB-L
rock ..... RK
round ..... RND
rounded ..... RNDD
rubbly ..... RBLY
rusty ..... RST

S
salt ..... SALT
saccharoidal ..... SACC
sample ..... SMPL
sand ..... SD
sandstone ..... SS
sandy ..... SDY
saturated ..... SAT
scales ..... SC
scarce ..... SCS
scattered ..... SCAT
schist ..... SCH
scolecondonts .... SCOL
secondary ..... SEC
sediment ..... SED
selenite ..... SEL
sericite ..... SER
severe ..... SEV
shale,-ly ..... SH,SHY
siderite ..... SID
silica ..... SIL
sillceous ..... SILIC
silky ..... SLKY
slit ..... SLT
siltstone ..... SLTST
size ..... SZ
slickensided ..... SLKS
slight ..... SL
small ..... S
smooth ..... SMTH
soft ..... SFT
soluble ..... SOLB
solution ..... SOL
sort ..... SRT
speck ..... SPCK
sphalerite ..... SPHAL
spherules ..... SPH
spicule ..... SPIC
splintery ..... SPL
sponge ..... SPG
spore ..... SPR
spot ..... SP
stain ..... STN
stained ..... STND
staining ..... STNG
stippled ..... STIP
strata ..... STRAT
streak ..... STR
striated ..... STRI
stringer ..... STRG
stromatoparoids . STROM
structure ..... STRUC
styolite ..... STYL
subangular .... SUBANG
subhedral ..... SUBHED
sucrose ..... SUC
sulphur ..... SULF
surface ..... SURF

T
tabular ..... TAB
texture ..... TEX
thick ..... THK
thin ..... THN
through ..... THRU
tight ..... TT
tourmaline ..... TOUR

trace ..... TR
transparent ..... TRNSP
trilobite ..... TRILO
tripolitic ..... TRIP
tubular ..... TUB
tuff ..... TUFF

U
unconformity .. UNCONF
unconsolidated . UNCONS
upper ..... UP

V
variable ..... VAR
varicolored ..... VCOL
variegated ..... VGTD
varved ..... VRVD
vein ..... VN
vertebrate ..... VRTB
very V
vesicular ..... VES
vitreous ..... VIT
volcanics ..... VOLC
vug,-gy,-ular ..... VUG

W
water ..... WTR
wavy ..... WVY
waxy ..... WXY
weather ..... WTHR
weathered ..... WTHRD
white ..... WH
with ..... W/

Y
yellow ..... YEL

Z
zone ..... ZN

5.10.4. Documentation

A field notebook will be kept for the bedrock ground water sampling. At a minimum, the field notebook will include project name and number, date and time, weather conditions, sampler's name, sample location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of boring locations will be included in the field notebook.

Test boring logs will be completed for the core description. Ground water sampling logs will be completed for the ground water sample. The field notebook will also note the sections of core sent for petrographic analysis. Chain-of-custody procedures will be followed for both the ground water samples and the core sections.

5.11. Shallow residential area ground water sampling

5.11.1. Rationale/design

Ecology and Environment (1998) identified several homes on Walnut Street and Judith Lane with private water wells. Shallow ground water samples will be collected at two sampling stations to evaluate if site-related constituents are migrating from Dead Creek toward these domestic wells (Figure 7). One sampling station will be located at the end of Walnut Street, and the other sampling station will be located on the east bank of Dead Creek at Judith Lane. Ground water samples at each of the two locations will be collected at the water table and at depths of 20 and 40 ft below ground surface which bracket the typical completion depth of domestic wells in southern Illinois. Push sampling technologies such as Geoprobe™, HydroPunch™, MicroWell™, Waterloo Profiler™, or equivalent sampling technology and low-flow sampling techniques will be used to collect six ground water samples.

Number of Ground Water Samples 6

Analyses	VOCs	USEPA Method 8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8290

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 8 is a sample and analysis summary of this activity.

5.11.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.11.3. Field procedure

Using direct push, a MicroWell™ will be installed at the water table at 20 ft below existing grade and 40 ft below existing grade. The MicroWell™ will be installed by driving a steel casing to the desired depth. A 2-inch, slotted, schedule 80 polyvinyl chloride (PVC) screen with a protective cotton sleeve and riser assembly will be threaded to an expendable point inside the steel casing. The steel casing will be removed, leaving the PVC screen and riser in

place. The formation material will be allowed to collapse, and the surface will be sealed with bentonite. A PID, an explosimeter, and a RAM will be used on a continuous basis to monitor these activities.

Polyethylene tubing will be placed down the center of the MicroWell™ to approximately two to three feet above bottom. A section of flexible tubing will be attached to the tubing and connected to a peristaltic pump. The free end of the flexible tubing will be positioned to discharge to a 5-gal bucket. The peristaltic pump will be turned on at an approximate flowrate of 100 ml/min, and purging will begin. Purging will continue for 60 minutes. Should the 5-gal bucket become nearly full, it will be replaced, and the full bucket will be emptied into a 55-gal drum. While the well is purging, sample bottle labels will be completed, and sample containers labeled. Turbidity, pH, and conductivity will be calibrated in accordance with the QAPP at the sampling locations and the data will be recorded in the field notebook and the ground water sampling log After 60 minutes, pH, conductivity, temperature, and turbidity will be measured and recorded in the field notebook and on ground water sampling logs. If the turbidity is greater than 5 NTU, purging will continue. Once the turbidity is at or below 5 NTU, samples will be collected. Should a turbidity level of 5 NTU be unachievable after 2 hours of purging, samples will be collected and the turbidity noted. The VOC sampling container will be filled first, followed by the remaining containers. After the sample containers are filled, they will be placed on ice in a cooler, and chain-of-custody procedures will be initiated. After sample collection, the MicroWells™ will be pulled, and the holes filled with bentonite.

5.11.4. Documentation

A field notebook will be kept for the MicroWell™ installation. At a minimum, the field notebook will include project name and number; date and time; weather conditions; sampler's name; sample location; limiting field conditions; problems encountered; subcontractor personnel on-site; USEPA Region V personnel on-site; other personnel on-site; and pH, conductivity, temperature, PID, explosimeter, RAM, and turbidity measurements. Ground water sampling logs with calibration values will also be completed. Notation of USEPA Region V acceptance of boring locations will be included in the field notebook.

5.12. Time-series sampling

5.12.1. Rationale/design

After collection and analysis of the shallow ground water vertical-profile samples at Walnut Street and Judith Lane, one MicroWell™ will be installed at each sampling station with its screened interval in the zone of highest detected constituent concentrations. USACE required stressing the aquifer at this sampling location. Time-series samples, as required by USACE, will be collected over a 24-hour period with samples collected at 0, 12, and 24 hours after the start of pumping in order to stress the saturated zone during sampling and evaluate constituent concentration trends. Pumping rates can not be determined in advance, but will be set so that the MicroWell™ can be pumped continuously for 24 hours without drying up.

Number of Ground Water Samples 6

Analyses	VOCs	USEPA Method 8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8290

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 9 is a sample and analysis summary of this activity.

5.12.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure

laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.12.3. Field procedures

MicroWells™ will be installed as described in section 5.9.3. Ground water samples will be collected using polyethylene tubing, flexible tubing, and a peristaltic pump, as described in section 5.9.3. The samples will be collected at the highest flow rate possible (approximately 3400 ml/min) with the peristaltic pump. Ground water samples will be collected when the pump is turned on (0 hr), 12 hours and 24 hours after initializing pumping. Conductivity, temperature, pH, and turbidity will be measured and recorded on the ground water sampling logs and in the field notebook. VOC containers will be filled first, then the remaining containers. Collected samples will be placed on ice in coolers, and chain-of-custody procedure will be initiated. After the 24-hr sample is collected, the MicroWell™ will be pulled, and the hole filled with bentonite.

5.12.4. Documentation

A field notebook will be kept for the MicroWell™ installation. At a minimum, the field notebook will include project name and number; date and time; weather conditions; sampler's name; sample location; limiting field conditions; problems encountered; subcontractor personnel on-site; USEPA Region V personnel on-site; other personnel on-site; and pH, conductivity, temperature, PID, explosimeter, RAM, and turbidity measurements. Ground water sampling logs with calibration values will also be completed. Notation of USEPA Region V acceptance or boring locations will be included in the field notebook.

5.13. Domestic well sampling

5.13.1. Rationale/design

Ground water samples will be collected from a total of four domestic wells on Walnut Street and Judith Lane that could be used for irrigation or drinking water supply. Preference will be given to sampling wells that were sampled in the past by the IEPA in order to provide some degree of historical record. Past domestic well sampling results, extracted from the 1998 Ecology and Environment report "Volume 1, Sauget Area 1, Data Tables/Map," and included in Appendix C of the SSP, as directed by the USACE.

Number of Ground Water Samples 4

Analyses	VOCs	USEPA Method 8260
	SVOCs	USEPA Method 8270
	Metals	USEPA Method 6010
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8290

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 10 is a sample and analysis summary of this activity.

5.13.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected,

unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.13.3. Field procedures

After the well owners have been contacted and permission obtained in writing to collect well water samples, the well owners will be contacted by O'Brien & Gere to set a time for well sampling. The domestic well samples will be collected from a tap as close as possible to the well head. Available information on well construction and pumps will be reviewed to evaluate the time the water should be allowed to run prior to sample collection for system purging. While the lines are purging, sample container labels can be completed and affixed to the sample containers. After 10 minutes, pH, conductivity, temperature, and turbidity measurements will be obtained. Then the VOC container will be filled, followed by the remaining containers. The sample containers will be placed on ice in a cooler, and chain-of-custody procedures initiated.

5.13.4. Documentation

A field notebook will be kept for the domestic well sampling. At a minimum, the field notebook will include project name and number, date and time, weather conditions, sampler's name, residence address, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Conductivity, pH, temperature, and turbidity measurements will also be recorded in the field notebook. Notation of USEPA Region V acceptance of sampling locations will be included in the field notebook.

5.14. Slug tests

5.14.1. Rationale/design

A considerable amount of information on the hydraulic characteristics of the American Bottoms aquifer is available from the Illinois Water Survey, Illinois Geological Survey and US Geological Survey. Public information, augmented by site-specific slug tests, may be all that is needed to design a pump and treat system should such a remedial measure be selected for a site. Performance of a pumping test on a high yield aquifer creates practical problems such as storage, treatment, and disposal of large volumes of pumped water. When it is necessary to design a pump and treat system, it may be simpler to use the best available information to design the recovery and treatment system and then add more recovery wells and treatment capacity if the system does not perform as expected. For these reasons, slug testing was selected as the preferred method for evaluating site-specific aquifer hydraulic characteristics.

To conduct the slug tests, three 2-inch diameter, stainless steel piezometers will be installed at each fill area (Sites G, H, I, L, and N) using the installation methods described in section 5.3.3. The slug tests at each fill area will be used to evaluate aquifer hydraulic conductivity. Slug tests will be conducted in the upper fine-grained zone, the middle fine sand zone, and the lower coarse sand zone typical of the American Bottoms aquifer in this area. These depths are estimated to be at 20, 40, and 60 ft, respectively, below ground surface. These depths will be confirmed in the field from the waste characterization boring activities.

Number of Slug Tests 15

5.14.2. QA/QC procedures

QA/QC procedures will consist of equipment test checks at each fill area and two repeat tests.

5.14.3. Field procedures

This section presents the field protocols for the completion of *in situ* hydraulic conductivity tests.

Equipment requirements.

- A pressure transducer connected to a data logger system
- An inert solid slug of sufficient diameter and length to artificially raise or lower the water level 1 ft or more in the well (commonly either a PVC or Teflon® slug)
- A timing device.

Test design.

A. Identify the test objectives and document them.

B. Identify potential limitations of test and interpretation methods as they relate to the project and site.

C. Identify the available database for correlation purposes (other hydraulic conductivity test data, maps, or logs of subsurface soils).

D. Evaluate access to wells and obstructions or siltation in wells.

E. Review boring and well completion logs for wells to be tested for lithology, natural discontinuities, possible well yield, screen length, location of ground water table with respect to the screen interval, and type of sand/gravel pack.

F. Identify the type of *in situ* hydraulic conductivity test to be used.

1. Only use a rising head test if the screened interval of the well straddles the water table. The introduction of water into the unsaturated portion of the formation during a falling head test will result in an inaccurate estimation of hydraulic conductivity.

2. If the screened interval of the well is fully submerged below the water, use both the rising or falling head test and average the results.

G. Evaluate the amount of head change to be induced in the well.

H. Evaluate the water level measurement frequency needed.

1. During the early portions of the test, measure water levels at closely spaced intervals. The frequency of measurements will be governed by the rate of recovery of the water level in the well. The faster the recovery, the more frequently the measurements need to be taken. Measurement frequency can decline logarithmically during the test (the length of time between measurements increasing during the test). Water levels should be recorded until the water level has recovered to 95% of static pre-test conditions.

I. Identify the type of slug and water level recording device to be used.

1. Choose the manual or electronic method based upon previously calculated hydraulic conductivity (K) values or expected K based upon grain size encountered within the well:

a. If $K > 10^{-3}$ cm/sec, use pressure transducer
b. If $K < 10^{-3}$ cm/sec, use pressure transducer or manual method.

Field protocols.

A. Record the following information in the project notebook and the slug test field log in Appendix F:
Name
Date
Project name and description
Project number
Weather conditions
Well number and well location in sufficient detail to relocate.

B. Measure and document static head. If a pressure transducer is to be used, lower transducer into well, and secure the pressure transducer cable to the well to prevent movement. Connect the pressure transducer to the electronic data logger. Measure the static head with both the transducer and manually, then start the automatic recording by the data logger.

C. Insert the slug into or withdraw the slug from the ground water in the well.

1. Given the variability of test conditions, there is no absolute requirement for the magnitude of the change in water level. It is suggested that a minimum of 1 ft instantaneous hydraulic head change be created to allow for effective measurement of aquifer response. About 75% of the

estimated displacement by the slug should be documented in the water level recordings.

D. Measure the recovery of the water level in the well until 95% recovery to static conditions has been achieved.

1. For manual measurements, record the time (real or elapse time) and the depth to ground water in the well in the project field book. All measurements should be from the same point on the well casing using the same well probe.

2. For the pressure transducer, the time and water level will be automatically recorded.

E. Data Review

1. Make sure the necessary information is documented for each test within the field notebook and on a slug test field log.

2. Make a preliminary analysis of data before leaving the field to evaluate if test was successful:

   a. Did the slug create an instantaneous head change in the well of sufficient magnitude to observe a meaningful water level response?

   b. Did you collect a sufficient number of data points to define the water level recovery for the test?

   c. Is the test data generally consistent with your pre-test expectations?

   d. If the test was not successful, reevaluate the test design and complete a new test.

3. For electronic tests, copy the data file onto a disk and label the disk with the project number, date, test well, and file name.

5.14.4. Documentation

A field notebook will be kept for the slug test evaluation. At a minimum, the field notebook will include project name and number, date and time, weather

conditions, tester's name, slug test location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of boring locations will be included in the field notebook. Slug test data will be downloaded from the data logger each day. The data will be reviewed for errors. If necessary, a slug test will be re-conducted.

5.15. Grain size analysis

5.15.1. Rationale/design

One soil boring will be completed adjacent to each fill area (Sites G, H, I, L, and N) to identify grain size of aquifer materials. Soil samples will be collected from the upper, middle, and lower aquifer zones (total of fifteen samples) using a Geoprobe™ or other suitable push technology. Sample locations will be selected in the field with the concurrence of the USEPA Region V or its designee. Each soil sample will be analyzed for grain size.

Number of Grain Size Analyses 15

Table 11 is a sample and analysis summary of this activity.

5.15.2. QA/QC samples

As this is a physical test, no QA/QC samples will be submitted.

5.15.3. Field procedure

A large bore (MacroCore®) soil sampler, using clear acetate liners, will be hydraulically pushed to collect a soil sample at specified depths. The collected sample will be placed into labeled plastic, wide-mouth containers and sealed. The MacroCore® sampler will collect approximately 1300 mL of material, which is sufficient for grain size analysis. Should larger (large gravel to cobble) size materials be encountered, additional core samples will be obtained and placed into additional containers. Collected samples will be placed into plastic coolers or corrugated boxes for shipment. Chain-of-custody procedures will be followed in order to track samples. The samples will be

submitted for grain size analysis using a sieve and hydrometer testing. Geoprobe™ holes will be filled with bentonite.

5.15.4. Documentation

A field notebook will be kept for the soil probing installation. At a minimum, the field notebook will include project name and number, date and time, weather conditions, sampler's name, sample location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of boring locations will be included in the field notebook.

5.16. Upgradient ground water sampling

5.16.1. Rationale/design

Existing wells EE-20, EE-04, and EEG-108 will be used as background (upgradient) ground water sampling locations. These wells, which are screened at depths of 23-28, 18-23, and 24-29 ft below ground surface, respectively, will be redeveloped as described in section 5.7. If these wells cannot be used, Geoprobe™, HydroPunch™, MicroWell™, Waterloo Profiler™, or equivalent sampling technology will be used to collect samples from the center of the former screened intervals at each of these locations using low-flow sampling techniques. In addition, ground water samples will be collected at depths of 60 and 100 ft below grade surface at each of these locations using push sampling technologies such as Geoprobe™, HydroPunch™, MicroWell™, Waterloo Profiler™, or equivalent sampling technology and low-flow sampling techniques. A sampling depth of 60 ft is approximately the midway between the screened interval of the existing shallow wells and the bottom of the aquifer, which is anticipated to be approximately 100 ft deep.

Number of Ground Water Samples 9

Analyses	VOCs	USEPA Method 8260
	SVOCs	USEPA Method 8270
	Metals	USEPA Method 6010
	Mercury	USEPA Method 7470A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8290

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 12 is a sample and analysis summary of this activity.

5.16.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.16.3. Field procedures

Field procedures for collection of upgradient ground water samples will follow the procedures for well redevelopment and collection of ground water in the fills areas, described in section 5.7.3.

5.16.4. Documentation

A field notebook will be kept for the upgradient ground water sampling. At a minimum, the field notebook will include project name and number, date and time, weather conditions, sampler's name, residence address, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Conductivity, pH, temperature, and turbidity measurements will also be recorded in the field notebook. Notation of USEPA Region V acceptance of sampling locations will be included in the field notebook.

5.17. Soil sampling

Soil samples will be collected in both undeveloped and developed areas that are susceptible to flooding and deposition of wind-blown dust. Specifically, floodplain soil sampling will be conducted in an area bounded by Queeny Road on the north, Falling Springs Road on the east, Illinois Route 157 on the south, and Illinois Route 3 (Mississippi Avenue) on the west. This is the area where water backs up at road crossings during heavy rains and where PCBs are known to occur in creek sediments. This area also includes most of the residential development in Sauget Area 1.

Information from the soil sampling program will be used to evaluate the extent of migration due to overbank flooding and wind-blown dust deposition. In addition, surficial and subsurface soil information will be used in the human health risk assessment (construction/utility worker and residential exposure scenarios). The Human Health Risk Assessment Work Plan is in Volume 1B of the SSP.

Floodplain soil samples will be collected every 200 ft on seven transects in undeveloped areas, a total of forty-five sampling stations. Based on these sampling results, twenty soil sampling stations will be located in developed areas. Three samples will be collected in developed areas adjacent to Transects 1, 2, 3, 4, 5, and 6, and two samples will be collected in developed areas adjacent to Transect 7, which is the transect at the downgradient limit of the residential area. Twenty developed area samples are considered an appropriate number for identification in the SSP until undeveloped area soil

samples and Creek Segment B, C, D, and E sediment samples are collected and analyzed. Then, this information on the extent and concentration of constituents in undeveloped area floodplain soils and creek sediments can be used to select developed area sampling locations.

5.17.1. Undeveloped area surface soil sampling

Rationale/design. Surficial (0 to 0.5 ft) soil samples will be collected every 200 ft on seven transects perpendicular to Dead Creek to evaluate the extent of migration via the surface water (overbank flow) and air (wind-blown dust) pathways (Figure 8). Sampling transects are placed in undeveloped areas adjacent to developed areas to allow ready access for sampling. VOC samples will be collected using EnCore® samplers per USEPA Method 5035.

Transect	Length	Number of Sampling Stations	Number of Surficial Soil Samples	Number of Subsurface Soil Samples
1	1,300'	7	7	7
2	1,000'	6	6	6
3	1,300'	7	7	7
4	1,300'	7	7	7
5	1,000'	6	6	6
6	800'	5	5	5
7	1,200'	7	7	7
Total		45	45	45

Number of Undeveloped Area Surficial Soil Samples 45

Analyses	VOCs	USEPA Method 5035/8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7471A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 13 is a sample and analysis summary of this activity.

5.17.2. Undeveloped area subsurface soil sampling

Rationale/design. Subsurface (0.5 to 6 ft) soil samples will be collected every 200 ft on seven transects perpendicular to Dead Creek to evaluate the extent of migration via the surface water (overbank flow) and air (wind-blown dust) pathways (Figure 8). Subsurface soil samples will be collected from 0.5 ft to 6 ft below ground surface. Visual observation (discoloration) and field PID readings will be used to identify the most impacted portion of the sample. This section will be selected for chemical analysis. Surface and subsurface soil sampling stations will be co-located. VOC samples will be collected using EnCore® samplers per USEPA Method 5035.

Number of Undeveloped Area Subsurface Soil Samples 45

Analyses	VOCs	USEPA Method 5035/8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7471A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 14 is a sample and analysis summary of this activity.

5.17.3. Undeveloped area soil dioxin sampling

Rationale/design. As directed by USACE, 20% of the surface soil samples will be analyzed for dioxin. To provide information for the human health risk assessment (construction/utility worker exposure), USEPA Region V directed

that 20% of the subsurface soil samples will be analyzed for dioxin. Visual observation (discoloration) and field PID readings will be used to identify the most impacted portion of the sample. This section will be selected for chemical analysis.

Number of Undeveloped Area Surface Soil Dixoin Samples	9
Number of Undeveloped Area Subsurface Soil Dioxin Samples	9

Analyses	Dioxin	USEPA Method 8280

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Tables 13 and 14 are sample and analysis summaries of this activity.

5.17.4. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.17.5. Field procedures

Surficial sampling. At the outset of surface soil sampling, follow these instructions. Surface soil samples will be discrete:

Discrete sample represents a single location in the soil column. This type of sample is also used for discrete analysis of surface soil conditions. Discrete soil samples are collected from near surface soils at locations identified in a work plan. Hand augers, disposable scoops, hand trowels, or shovels are used to collect these samples.

Use the following procedure to collect a sample:

1. If necessary, penetrate the soil to the appropriate sampling depth.

2. Using a clean tool, remove and discard a thin layer of soil from the area. Record the characteristics of the soils including grain size, content, staining, and color.

3. To collect a discrete soil sample for VOC analysis, a 5-gram EnCore® sampler will be used. After pressing the sampler into the soil at the sampling location, cap the coring body while it is still in the EnCore® sampler T-handle. To collect a discrete soil sample for other parameters, use a stainless steel laboratory spoon or equivalent. Homogenize the non-VOC samples as necessary.

4. Place the homogenized sample into appropriate sample containers. In addition to analytical samples, a reference sample considered representative of the soil may also be collected in a wide mouth jar and stored for possible future physical analyses such as grain size analysis.

5. Check that the cap of each sample container has a Teflon® liner, if required for the analytical method. Secure the cap tightly.

6. Label the sample container with the appropriate sample tag. The tags could be permanent labels or clean tape. Label the tag carefully and clearly using indelible ink. Complete appropriate sampling forms and record in the field notebook. Pre-labeled containers are handy, particularly if you are wearing gloves or if the weather is inclement.

7. Initiate the chain-of-custody form.

8. Place the capped EnCore® sampler core bodies and other sample containers on ice in a cooler to maintain the samples at approximately 4 °C. Ship the cooler to the laboratory for analysis within 48 hr of sample collection.

9. Decontaminate equipment between sample locations and after use as described in section 5.7.3.

Subsurface sampling. A steel hand auger will be used to collect soil samples at a depth of 0.5 to 6 ft below existing grade. Soil samples will be collected by placing a 4 ft by 4 ft piece of plastic sheeting on the ground over the location where the surface soil sample was collected. A hole will be cut in the plastic sheeting for insertion of the hand auger. The hand auger will then be used to make a borehole in the soil. Soil between the surface and 3 ft below existing grade will be placed on the plastic sheeting. Upon reaching a depth of 3 ft below existing grade, collected soil samples will be placed into labeled, laboratory-supplied, clean sample containers. A 5-gram EnCore® sampler will be used to collect VOC samples from the subsurface. After collection of soil in the hand auger and before homogenization, the EnCore® sampler will be used to collect a VOC sample from the hand auger. Filled, labeled and capped EnCore® sampler core bodies and sample containers will be placed on ice in a cooler. Chain-of-custody procedures will be followed. The borehole will be filled with bentonite. The surface (top 2 ft) will be restored with soil and seeded. Boring-generated soils will be contained and transported to the centrally located solid waste disposal container. General waste will be contained in plastic bags and disposed of in a general refuse container.

Should hand augering prove impractical, a direct push technology will be used to collect the soil sample. The soil sample will be collected using the MacroCore® sampler. The MacroCore® sampler will have a clear acetate liner. The push sample will be collected from 3 to 6 ft below grade. A VOC sample will be collected from the top portion of the sample using a 5-gram EnCore® sampler. The remaining portion will be homogenized in a stainless steel bowl and used to fill the remaining sample containers. The collected samples will be placed on ice in a cooler, and chain-of-custody procedures will be followed. The boreholes will be filled with bentonite. A PID, an explosimeter, and a RAM will be used on a continuous basis to monitor these activities.

5.17.6. Documentation

A field notebook will be kept for the soil boring installation. At a minimum, the field notebook will include the project name and number; date and time; weather conditions; sampler's name; sample location; depth of boring; PID, explosimeter, and RAM readings; limiting field conditions; problems encountered; subcontractor personnel on-site; USEPA Region V personnel on-site; and other personnel on-site. Notation of USEPA Region V acceptance of boring locations will be included in the field notebook.

5.18. Soil sampling, developed areas

5.18.1. Developed area surface soil sampling

Rationale/design. Surficial soil samples (0 to 0.5 ft below ground surface) will be collected in at least twenty locations in developed areas. Soil samples will be collected at three residences adjacent to Transects 1 to 6 and at two residences adjacent to Transect 7.

Number of Developed Area Surface Soil Samples 20

Analyses	VOCs	USEPA Method 5035/8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7471A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 15 is a sample and analysis summary of this activity.

5.18.2. Developed area subsurface soil sampling

Rationale/design. Subsurface soil samples (0.5 to 6 ft below ground surface) will be collected in at least twenty locations in developed areas. Soil samples will be collected at three residences adjacent to Transects 1 to 6 and at two residences adjacent to Transect 7. Visual observation (discoloration) and field PID readings will be used to identify the most impacted portion of the sample. This section will be selected for chemical analysis. VOC samples will be collected using EnCore® samplers per USEPA Method 5035.

Number of Developed Area Subsurface Soil Samples 20

Analyses	VOCs	USEPA Method 5035/8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7471A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 16 is a sample and analysis summary of this activity.

5.18.3. Developed area soil dioxin sampling

Rationale/design. Ad directed by USACE, 20% of the surface soil samples will be analyzed for dioxin. To provide information for the human health risk assessment (construction/utility worker exposure), USEPA Region V directed that 20% of the subsurface soil samples will be analyzed for dioxin. Visual observation (discoloration) and field PID readings will be used to identify the most impacted portion of the sample. This section will be selected for chemical analysis.

Number of Developed Area Surface Soil Dixoin Samples	4
Number of Developed Area Subsurface Soil Dioxin Samples	4

Analyses	Dioxin	USEPA Method 8280

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Tables 15 and 16 are sample and analysis summaries of this activity.

5.18.4. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling

technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.18.5. Field procedures

Field procedures for collection of surface and subsurface soil samples in developed areas will follow the procedures for collection of surface and subsurface soil samples in undeveloped areas as described in section 5.17.5.

5.18.6. Documentation

A field notebook will be kept for surface and subsurface soil sampling. At a minimum, the field notebook will include the project name and number; date and time; weather conditions; sampler's name; sample location; depth of boring; PID, explosimeter, and RAM readings; limiting field conditions; problems encountered; subcontractor personnel on-site; USEPA Region V personnel on-site; and other personnel on-site. Notation of USEPA Region V acceptance of surface and subsurface soil sampling locations will be included in the field notebook.

5.19. Background soil samples

5.19.1. Rationale/design

Background soil samples will be collected at the locations of the background ground water wells, specifically existing wells EE-20, EE-04 and EEG-108 which are east of Sites I, H, and L, respectively. Samples will be collected

from depths of 0 to 0.5 ft and 0.5 to 6 ft below ground surface. Visual observation (discoloration) and PID readings will be used to identify the most impacted portion of the sample for analysis. VOC samples will be collected using EnCore® samplers per USEPA Method 5035.

Number of Background Soil Samples 6

Analyses	VOCs	USEPA Method 5035/8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7471A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8280

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 17 is a sample and analysis summary of this activity.

5.19.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.19.3. Field procedures

Field procedures for collection of background soil samples will follow the procedures for collection of soil samples in the undeveloped areas, described in section 5.17.5.

5.19.4. Documentation

A field notebook will be kept for background soil sampling. At a minimum, the field notebook will include the project name and number; date and time; weather conditions; sampler's name; sample location; depth of boring; PID, explosimeter, and RAM readings; limiting field conditions; problems encountered; subcontractor personnel on-site; USEPA Region V personnel on-site; and other personnel on-site. Notation of USEPA Region V acceptance of background soil sampling locations will be included in the field notebook.

5.20. Sediment sampling

Vertically integrated sediment samples will be collected in Dead Creek to evaluate the extent of downstream migration of site-related constituents and to provide information for use in the human health risk assessment (recreational teenage and recreational fishing scenarios) and the ecological risk assessment (endpoint organism exposure to sediments). The Human Health Risk Assessment Work Plan is in Volume 1B of the SSP, and the Ecological Risk Assessment Work Plan is in Volume 1C. It should be noted that sediment samples will be collected beginning at the most downgradient location and after collection of surface water samples. Given the 17,000-ft length of Dead Creek, sediment sampling at 400-ft intervals will provide sufficient information to evaluate the extent of downstream migration of industry-specific constituents. As directed by USEPA Region V, sediment samples will be collected at 200-ft intervals in the undeveloped portions of Dead Creek (*i.e.*, Creek Segments B and F) and at 150-ft intervals in the developed portions of Dead Creek, specifically Creek Segments C, D, and E, to evaluate the extent of migration of industry-specific constituents. A 150-ft sediment sampling interval was used in the 1991 Geraghty & Miller investigation of Creek Segment B; therefore, repeating sample collection at a

150-ft interval is not considered appropriate in this creek segment even though its southern end passes through a developed area. For this reason, sediment samples will be collected at 200-ft intervals in Creek Segment B. Sediment samples will be collected every 1000 ft in Dead Creek to evaluate the extent of migration of site-related constituents.

As directed by USACE, sediment sampling locations in Creek Segments B, C, D, E, and the portion of Creek Segment F upstream of Borrow Pit Lake will be adjusted in the field so that samples are obtained at the upstream and downstream ends of each road culvert at a specified radial distance from the culvert. Samples will be collected within a radial distance of 10 ft from the upstream and downstream end of each road culvert.

The extent of migration information collected as part of this task, coupled with sediment thickness measurements and channel cross-sectional area, will provide enough information to evaluate the volume of impacted sediments.

Sediment samples will not be collected in Creek Segment A. This creek segment was used as a storm water detention basin which was dredged a number of times to remove accumulated sediment. Dredge spoil was placed on the creek banks and Site I. Cerro Copper performed an IEPA-approved remedial action for Creek Segment A in 1990 and 1991. Approximately 20,000 yd^3 of impacted sediments were excavated from depths of 10 to 15 ft below grade and transported off site for disposal at the Waste Management landfill in Emelle, Alabama. After excavation, an HDPE vapor barrier was installed, and Creek Segment A was backfilled. The site is now fenced and used as a controlled-access truck parking lot. Since Creek Segment A was remediated under an agreement with IEPA, no further characterization is considered necessary.

5.20.1. Undeveloped area sediment sampling

Rationale/design. Vertically integrated sediment core samples will be collected at 200-ft intervals in Creek Segment B and Creek Segment F to evaluate the extent of downstream migration of constituents related to specific industrial sources located at the upstream end of Dead Creek (Figure 9). The combined length of these creek segments is approximately 10,000 ft. Industry-specific constituents include PCBs (discontinued chemical manufacturing operation), total petroleum hydrocarbons (TPH) (closed oil refinery), copper (active metal refining), and zinc (active metal refining). This information will also be used in the human health risk assessment.

Samples will be collected in depositional areas at the thickest sediment profile. Channel cross-section will be surveyed at each sampling station, and sediment depth will be measured at three locations perpendicular to the channel (channel center, half way between channel center and right channel edge, and half way between channel center and left channel edge).

Number of Sediment Samples		50
Analyses	PCBs	USEPA Method 680
	TPH	USEPA Method 8015B
	Copper	USEPA Method 7211
	Zinc	USEPA Method 7951
	TOC	USEPA Method 9060
	Grain Size	Physical Method
	Solids Content	USEPA Method SM2540G

Savannah Laboratories, which will perform the sediment analyses, does not have a procedure in their QAPP for analyzing zinc by AA. Savannah Laboratories has all the necessary equipment to conduct this analysis, but does not have the necessary lamp. This lamp will be purchased prior to the start of sample collection.

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 18 is a sample and analysis summary of this activity.

QA/QC samples. QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MS/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum

required is one per ten or fraction of ten environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples.

Field procedures. Creek channel cross-sections will be completed prior to collecting sediment samples for volumetric calculation. Sediment samples will be collected at the thickest part of the sediment profile as identified by the surveyors. Sediment samples will be collected using a manual push-type sediment core sampler. The sampler consists of a PVC barrel, polycarbonate (Lexan®) liner, check valve, extension rods, and a "T" handle. A liner will be placed into the bottom of the tube and secured in place. The sampler will then be pushed into the sediment, collecting a sediment sample from 0 to 12 inches below the sediment layer. The sediment will be pulled up, creating a slight vacuum that closes the check valve. The tube will be removed from the sample, and the sediment will be placed into the sample containers. Where water depths require, extensions will be added to the sample tube to facilitate collecting the sediment sample. In these instances, a boat will be used to reach the sampling location. In Dead Creek, a ladder will be used as necessary to facilitate sample collection. Sample containers will be placed on ice in coolers. Chain-of-custody procedures will be followed. After each sampling location or when all decontaminated sampling equipment has been used, decontaminate the sampling equipment according to the procedures outlined in section 5.7.3.

Documentation. A field notebook will be kept for the sediment sampling activity. At a minimum, the field notebook will include the project name and number, date and time, weather conditions, sampler's name, sample location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of sampling locations will be included in the field notebook.

5.20.2. Developed area sediment sampling

Rationale/design. Vertically integrated sediment core samples will be collected at 150-ft intervals in Creek Segments C, D, and E to evaluate the extent of downstream migration of constituents related to specific industrial sources located at the upstream end of Dead Creek (Figure 9). The combined length of these creek segments is approximately 7000 ft. Industry-specific constituents include PCBs (discontinued chemical manufacturing operation), TPH (closed oil refinery), copper (active metal refining), and zinc (active metal refining). This information will also be used in the human health risk assessment.

Samples will be collected in depositional areas at the thickest sediment profile. Channel cross-section will be surveyed at each sampling station, and sediment depth will be measured at three locations perpendicular to the channel (channel center, half way between channel center and right channel edge, and half way between channel center and left channel edge).

Number of Sediment Samples 47

Analyses	PCBs	USEPA Method 680
	TPH	USEPA Method 8015B
	Copper	USEPA Method 7211
	Zinc	USEPA Method 7951
	TOC	USEPA Method 9060
	Grain Size	Physical Method
	Solids Content	USEPA Method SM2540G

Savannah Laboratories, which will perform the sediment analyses, does not have a procedure in their QAPP for analyzing zinc by AA. Savannah Laboratories has all the necessary equipment to conduct this analysis, but does not have the necessary lamp. This lamp will be purchased prior to the start of sample collection.

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 19 is a sample and analysis summary for this activity.

QA/QC samples. QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MS/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples.

Field procedures. Field procedures for the collection of sediment samples for developed areas will follow the procedures for sediment sample collection as outlined in section 5.20.1.

Documentation. A field notebook will be kept for the sediment sampling activity. At a minimum, the field notebook will include the project name and number, date and time, weather conditions, sampler's name, sample location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of sampling locations will be included in the field notebook.

5.20.3. Borrow pit lake sediment sampling

Rationale/design. A 200-ft sediment sampling interval was used for Dead Creek to define downstream concentration distributions and gradients. Since half of the 6000-ft long Borrow Pit Lake lies north of the point where Dead Creek discharges into it, two sediment sampling stations were considered adequate for the upstream portion of Borrow Pit Lake. Sampling at 200-ft intervals in the portion of Borrow Pit Lake north of the discharge of Dead Creek as requested by the USEPA Region V would result in a total of fifteen samples, which is more data than is needed to define the distribution of industrial source-specific constituents resulting from the discharge of Dead Creek into Borrow Pit Lake. A 400-ft sampling interval, a total of eight samples, in the northern half of Borrow Pit Lake will provide enough information to define the distribution of sediments resulting from the discharge of Dead Creek into Borrow Pit Lake.

Therefore, vertically integrated sediment core samples will be collected at 400-ft intervals from upstream end of Borrow Pit Lake in Creek Segment F down to the confluence of Dead Creek with the lake in order to evaluate the distribution of constituents related to specific industrial sources located at the upstream end of Dead Creek (Figure 9). Industry-specific constituents include PCBs (discontinued chemical manufacturing operation), TPH (closed oil refinery), copper (active metal refining), and zinc (active metal refining). This information will also be used in the human health risk assessment.

Samples will be collected along the center line of the lake. While sediment deposition is likely at the point where Dead Creek enters Borrow Pit Lake, sediment transport north of the confluence will be limited by backwater depositional processes and streamflow into the north end of the lake.

Number of Sediment Samples 8

Analyses	PCBs	USEPA Method 680
	TPH	USEPA Method 8015B
	Copper	USEPA Method 7211
	Zinc	USEPA Method 7951
	TOC	USEPA Method 9060
	Grain Size	Physical Method
	Solids Content	USEPA Method SM2540G

Savannah Laboratories, which will perform the sediment analyses, does not have a procedure in their QAPP for analyzing zinc by AA. Savannah Laboratories has all the necessary equipment to conduct this analysis, but does not have the necessary lamp. This lamp will be purchased prior to the start of sample collection.

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 20 is a sample and analysis summary for this activity.

QA/QC samples. QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MS/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples.

Field procedures. Field procedures for the collection of sediment samples for Borrow Pit Lake will follow the procedures for sediment sample collection as outlined in section 5.20.1.

Documentation. A field notebook will be kept for the sediment sampling activity. At a minimum, the field notebook will include the project name and

number, date and time, weather conditions, sampler's name, sample location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of sampling locations will be included in the field notebook.

5.20.4. Dead Creek sediment sampling

Rationale/design. Vertically integrated sediment core samples will be collected every 1000 ft in Dead Creek, from the upstream end of Creek Segment B to the downstream end of Creek Segment F at the Old Prairie du Pont Creek lift station, to evaluate the extent of downstream migration of target compound list/target analyte list (TCL/TAL) constituents (Figure 10). These broad-scan analyses are also intended to provide information for the human health risk assessment.

Two sediment core samples will be collected in Borrow Pit Lake in Creek Segment F upstream of the discharge of Dead Creek to assess the effect of backwater conditions and/or the contributions of other sources. One sample will be collected upstream, and one sample will be collected downstream of the confluence of Dead Creek and Old Prairie du Pont Creek to evaluate the impact of the Dead Creek discharge on sediment quality in Old Prairie du Pont Creek.

The location of the upstream sample in Old Prairie du Pont Creek will be collected at an appropriate distance from the confluence with Dead Creek so that possible previous effects of flooding and flow reversals will not affect the collection of the background sample. As reported in the 1996 HRS package prepared by PRC Environmental Management, Inc. for USEPA Region V, a background sampling station was located 200 ft north of the confluence of Dead Creek and Old Prairie du Pont Creek. The sediment background sample will be collected at this location.

Samples will be collected in depositional areas at the thickest sediment profile. Channel cross-section will be surveyed at each sampling station and sediment depth will be measured at three locations perpendicular to the channel (channel center, half way between channel center and right channel edge, and half way between channel center and left channel edge).

Number of Sediment Samples	20	
Analyses	VOCs	USEPA Method 5035/8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7471A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8290
	TOC	USEPA Method 9060
	Grain Size	Physical Method
	Solids Content	USEPA Method SM2540G

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 21 is a sample and analysis summary for this activity.

QA/QC samples. QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MS/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

Field procedures. Dead Creek sediment samples will be collected using the same equipment and methods as described in section 5.20.1. However, VOC samples will be collected using EnCore® samplers per USEPA Method 5035.

Documentation. A field notebook will be kept for the sediment sampling activity. At a minimum, the field notebook will include the project name and

number, date and time, weather conditions, sampler's name, sample location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of sampling locations will be included in the field notebook.

5.20.5. Ecological sediment sampling

Rationale/design. In support of the Ecological Assessment Sampling Plan, sediment samples will be collected at the number of sampling stations indicated at each of the following locations:

- Creek Segment B - 3 sampling stations
- Creek Segment C - 3 sampling stations
- Creek Segment D - 3 sampling stations
- Creek Segment E - 3 sampling stations
- Creek Segment F, between Route 157 and Borrow Pit Lake - 3 sampling stations
- Creek Segment F, in Borrow Pit Lake - 3 sampling stations
- Reference Area 1 - 2 sampling stations
- Reference Area 2 - 2 sampling stations
- Site M - 1 sampling station.

Each sediment sampling station will coincide with the location where Menzie-Cura will be collecting ecologicial samples for evaluation and will be collected during the ecological sample collection activities. The three sampling stations within Creek Segment B, C, D, E, F, and Borrow Pit Lake will be selected so that they approximately coincide with the maximum, average, and minimum concentrations of site-related constituents detected in each creek segments during the sediment sampling and analysis program designed to delineate the extent of migration of the industry-specific constituents, as discussed in sections 5.20.1, 5.20.2, and 5.20.3. The two sampling stations in each Reference Area 1 and Reference Area 2 will be either in the Dead Creek watershed or in a watershed that includes industrial, commercial, residential, and farming land uses. The areas will be comparable to those found in the Dead Creek watershed in order to provide a basis for comparison with Dead Creek. The exact locations will be determined after the Ecologicial Assessment Site Reconnaissance Survey is performed. Additionally, one sampling station will be selected at Site M.

The sediment samples collected for the Ecological Assessment will assist in the evaluation of the extent of downstream migration of target compound

list/target analyte list (TCL/TAL) constituents (Figure 11). These broad-scan analyses are also intended to provide information for the ecological risk assessments.

Samples will be collected from the biological active zone of the sediment. This zone is approximately within the top six inches of the sediment. VOC samples will be collected using a 5-gram EnCore® sampler per USEPA Method 5035.

Number of Ecologicial Sediment Samples 23

Analyses	VOCs	USEPA Method 5035/8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010B
	Mercury	USEPA Method 7471A
	Cyanide	USEPA Method 9010B
	PCBs	USEPA Method 680
	Pesticides	USEPA Method 8081A
	Herbicides	USEPA Method 8151A
	Dioxin	USEPA Method 8290

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 22 is a sample and analysis summary for this activity.

QA/QC samples. QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MS/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

Field procedures. Sediment samples for the ecological assessment will be collected using a tall Ekman grab sampler. The Petite Ponar grab sampler with sliding screens will be used as a back-up sampling devise. The Ekman grab sampler will either be deployed over the side of a boat or by wading depending upon the depth of the surface water body. Sampling will begin at the furthest downstream sediment sampling station and proceed upstream. It is the intent of the ecological sediment sampling to collect sediment samples from 0 to 6 inches below the sediment layer. Due to the volume of sediment required to perform the chemical analysis and the toxicity testing for the ecological assessment, it has been estimated that six to eight grab samples will need to be collected at each sampling location. The following procedures will be followed for the collection of the ecological sediment samples:

- Identify the sampling location and document it in the field logbook.
- Position the boat stern at the sampling point and drop anchor from the bow. Should wading be employed for sample collection, sampler should be positioned upstream of the sample point.
- Pre-label sample containers.
- Don protective clothing.
- Deploy grab sampler with open jaws slowly, hand over hand, over the side of the boat.
- When sampler feels the grab sampler has penetrated the bottom sediment, send the messenger down the grab sampler line to activate the closure mechanism of the jaw or trigger with a pole in shallow waters.
- Slowly retrieve the grab sampler by slowly pulling to the surface.
- When the grab sampler is visible and along side of the boat, a field assistant will be ready with a bin to place the grab sampler in.
- Carefully decant excess water from the grab sampler and remove the mesh screen for access to the sediments.
- Measure the depth of the sediments in the grab sampler using a decontaminated ruler. There should be at least 6 inches (15 centimeters) of sediments in the grab sampler for collection of samples for evaluation.

- If enough sediment depth was obtained, first collect a sediment sample for VOC analysis from the grab sampler using an EnCore® sampler. Follow the general EnCore® sample collection procedures as discussed in section 5.17.5.

- The remaining samples for chemical analysis and toxicity testing will be obtained from subsequent homogenized grab samples collected at the same sampling point. Decontaminated stainless steel spoons and bowls will be used for homogenization. As stated previously, it is anticipated that six to eight grab samples will be necessary at each location to obtain the necessary amount of sediment sample volume.

- Place the homogenized samples into appropriate containers and complete the sample labels.

- Place the samples in a cooler on ice.

- Initiate chain-of-custody procedures for samples collected.

- After each sampling location or when all decontaminated sampling equipment has been used, decontaminate the sampling equipment according to the procedures outlined in section 5.7.3.

Documentation. A field notebook will be kept for the sediment sampling activity. At a minimum, the field notebook will include the project name and number, date and time, weather conditions, sampler's name, sample location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of sampling locations will be included in the field notebook.

5.21. Surface water sampling

5.21.1. Rationale/design

Surface water samples will be collected to evaluate the extent of downstream migration of site-related constituents and to provide information for use in the human health risk assessment (trespasser and recreational fishing scenarios) and the ecological risk assessment (endpoint organism exposure to surface water). The Human Health Risk Assessment Work Plan is in Volume 1B of the SSP and the Ecological Risk Assessment Work Plan is in Volume 1B.

Surface water samples will be collected every 1000 ft in Dead Creek, from the upstream end of Segment B to the downstream end of Segment F at the Old Prairie du Pont Creek lift station, to evaluate the extent of downstream migration of site-related constituents (Figure 10).

Two surface water samples will be collected in Borrow Pit Lake in Creek Segment F upstream of the discharge of Dead Creek to assess the effect of backwater conditions and/or the contributions of other sources. One sample will be collected upstream and one sample will be collected downstream of the confluence of Dead Creek and Old Prairie du Pont Creek to evaluate the impact of the Dead Creek discharge on surface water quality in Old Prairie du Pont Creek.

The location of the upstream sample in Old Prairie du Pont Creek will be collected at an appropriate distance from the confluence with Dead Creek so that possible previous effects of flooding and flow reversals will not affect the collection of the background sample. As reported in the 1996 HRS package prepared by PRC Environmental Management, Inc. for USEPA Region V, a background sampling station was located 200 ft north of the confluence of Dead Creek and Old Prairie du Pont Creek. The surface water background sample will be collected at this location.

Samples will be collected at a depth of 0.6 ft of the creek water column (measured from the top of the water column).

Number of Surface Water Samples		20
Analyses	VOCs	USEPA Method 8260B
	SVOCs	USEPA Method 8270C
	Metals	USEPA Method 6010A
	Mercury	USEPA Method 7470A

Cyanide	USEPA Method 9010B
Fluoride	USEPA Method 300.0
Total Phosphorus	USEPA Method 365.4
Ortho-phosphate	USEPA Method 300.0
PCBs	USEPA Method 680
Pesticides	USEPA Method 8081A
Herbicides	USEPA Method 8151A
Dioxin	USEPA Method 8290
TSS	USEPA Method 160.2
TDS	USEPA Method 160.1
Hardness	USEPA Method 130.1/130.2
pH	USEPA Method 150.1/150.2

Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Table 23 is a sample and analysis summary of this activity.

5.21.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler containing environmental samples for VOC analysis that is shipped.

5.21.3. Field procedures

Sampling procedures for collecting surface water samples were developed using sample collection techniques, equipment, and materials described in the

USEPA Region V document, *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels* (USEPA 1996) as guidance. The degree of protection from sample contamination during collection, transport, and analysis provided in Method 1669 was developed assuming laboratory analytical method detection limits as low as tenths of a part per trillion. At the part per trillion method detection limit, outside contaminants must be eliminated. To this end, stringent and certifiable cleaning of all sampling equipment and materials, non-metallic sample collection materials and containers, and four sample collection techniques are included in the Method 1669.

Analytical methodologies and method detection limits have been developed to meet the objectives of this project and are described and listed in the QAPP. The project method detection limits for metals analyses are 1 to 3 orders of magnitude higher than those in Method 1669. For this reason, many of the requirements of Method 1669 are not applicable to this project. The types of protective gloves, tubing materials, container materials, sampling team members and their responsibilities, and specific sample collection techniques and equipment have been adopted from Method 1669. For this sampling activity, Teflon® tubing, Teflon® barbed hose connectors, styrene/ethylene/butylene/silicone (SEBS) flexible tubing, and laboratory-preserved sample containers will be used.

Samples will be collected using a flat-bottom boat. Sampling equipment will be placed into the boat. Personal flotation devices will be worn by the sampling team. A third team member will remain on shore with the throwable flotation device. Sampling will be performed from downstream to upstream. The boat will be paddled to the first sampling location and anchored in place with the bow facing upwind or upstream as appropriate. Once at the sampling location, clean, non-talc gloves will be put on by both team members. An appropriate length of SEBS tubing will be removed from the roll of tubing and cut. One team member will affix the Teflon® weight to the inlet end of the tubing, and attach the tubing to the 3-ft PVC extension. Enough extra tubing will be used so the inlet can be placed at approximately 0.6x (ft of creek water column, where "x" is the total depth of the water column) measured from the top of the water column. Water depth will be measured and sampling depth established prior to sampling. The PVC extension will be firmly fixed into its holder. The flexible tubing will then be connected to the peristaltic pump head. Sufficient flexible tubing will then be pulled from the roll so the discharge end extends 6 to 12 inches off the stern of the boat. The flexible hose will be fixed to the bottom of the boat with duct tape to minimize tripping hazards. The peristaltic pump will be turned on and operated at an approximate flow rate of 100 ml/min and allowed to pump for 5 minutes to

purge the collection tubing. While purging in continuing, sample labels can be completed and affixed to the sample containers. A new pair of non-talc gloves will be put on by both team members and samples will be collected, filling the VOC sample containers first. Metals samples will be collected last.

As a sample container is filled and securely capped, it will be placed on ice in a cooler. Once the sample containers have been filled and placed in the cooler, the chain-of-custody form will be completed. As the chain-of-custody form is being completed, the second team member will disconnect the flexible tubing from the peristaltic pump and extension and place it into a plastic trash bag for disposal. The anchor will then be pulled, the boat will be positioned to collect the next sample, and the sampling procedure will be repeated. Sampling equipment decontamination will follow the procedure described in section 5.7.3.

If, during surface water collection in Dead Creek, it is found that using the boat is not feasible, the samples will be collected from the bank by fixing the inlet end to an extendable, non-metallic rod and holding the inlet in the creek. The discharge end of the tubing will be held in a position to discharge over the creek bank downstream of the inlet.

5.21.4. Documentation

A field notebook will be kept for the surface water sampling. At a minimum, the field notebook will include the project name and number, date and time, weather conditions, sampler's name, sample location, sample collection times, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of sampling locations will be included in the field notebook.

5.22. Air sampling

5.22.1. Rationale/design

Ambient air sampling will be conducted to determine the tendency of site constituents to enter the atmosphere and local wind patterns. Air sampling data will be used in the human health risk assessment (construction/utility worker and residential exposure scenarios). The Human Health Risk Assessment Work Plan is in Volume 1B of the SSP.

Volatile organics. Twenty-four-hour cumulative duration sorbent tube samples will be collected over a 1-day period using TO-1 (attached as Appendix G) sampling protocols in order to evaluate the tendency of site constituents to enter the atmosphere and local wind patterns. Two upwind and two downwind sorbent tube samplers will be installed around Site G, and three upwind and six downwind sorbent tube samplers will be installed at Sites H, I, and L. Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Number of Volatile Organic Air Samples 13

Analyses	VOCs	USEPA Method TO-1

Semivolatile organics, PCBs, and dioxins. Twenty-four-hour cumulative duration polyurethane foam (PUF) samples will be collected over a 1-day period using TO-13, TO-4, and TO-9 (attached as Appendix G) sampling protocols in order to evaluate the tendency of site constituents to enter the atmosphere and local wind patterns. Two upwind and two downwind PUF samplers will be installed around Site G, and three upwind and six downwind PUF samplers will be installed at Sites H, I, and L. Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Number of Semivolatile Organic Air Samples 13

Analyses	SVOCs	USEPA Method TO-13
	PCBs	USEPA Method TO-4
	Dioxin	USEPA Method TO-9

Metals. Twenty-four-hour cumulative duration PM 2.5 samples will be collected over a 1-day period in order to evaluate the tendency of site constituents to enter the atmosphere and local wind patterns. Two upwind and two downwind PM 2.5 samplers will be installed around Site G, and three upwind and six downwind PM 2.5 samplers will be installed at Sites H, I, and L. Sampling locations will be selected in the field with the concurrence of USEPA Region V or its designee.

Number of Metals Air Samples	13	
Analyses	Metals	USEPA Method 6010B

Degree of hazard. Organic and inorganic constituents detected will be compiled into a data base. Frequency of detection, average, maximum, minimum and 95% confidence interval concentrations will be compiled for each detected constituent along with information on degree of hazard. This information will be used in the human health risk assessment. The Human Health Risk Assessment Work Plan is in Volume 1B of the SSP.

Ambient air sample collection is required to measure airborne levels of VOCs, SVOCs, PCBs, dioxin, and metals that may be evolving from the site. An air sample collection and analytical test method is required to measure airborne constituent levels over a 24-hour time period. A 24-hour sample duration is required to average the air emission differences that may occur from the day time to night time cycle from on-site and off-site conditions and activities. Also, air sample collection locations need to be positioned on the site to collect up wind and down wind samples for differentiation of constituents originating from the surrounding area and those originating from the site. The sample protocol will collect site samples over a 1-day time period on a very warm, dry day.

The level of detection for SVOCs required by USEPA Region V needs to consider sensitivity and selectivity to analyze complex samples. Based on this need, the analytical method of choice is gas chromatography coupled with mass spectrometry (GC/MS) for detection. Based on the GC/MS analytical method and its sensitivity level, the air sample volume needs to exceed 325 standard cubic feet (scf) to collect a quantity of SVOCs that meet the level of detection required by USEPA Region V.

The sample collection method to meet the above requirements for SVOCs measurement is USEPA Method TO-13 as identified in *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air* (June 1988). This method will use a Graseby/General Metal Works, Inc. high volume air sampling unit for sample collection. Sample collection will consist of drawing an ambient air sample at a high volume flow rate through a PUF collection media over a 24-hour time period. The samples will be submitted for analysis of the TO-13 list of SVOCs.

The sample collection method for VOC measurement is USEPA Method TO-1. The sampling method for PCB measurement is USEPA Method TO-4. The sampling method for dioxin measurement is USEPA Method TO-9. The sampling method for metals measurement is PM 2.5.

Table 24 is a sample and analysis summary of this activity.

5.22.2. QA/QC samples

QA/QC samples will consist of one duplicate per ten, or fraction of ten, environmental samples collected and one MSD/MSD or spike duplicate per twenty, or fraction of twenty, environmental samples collected. Duplicate, MS/MSD, and spike duplicate samples will be submitted for analysis. Duplicate samples are collected to measure consistency of field sampling technique. MS/MSD and spike duplicate samples are collected to measure laboratory quality control procedures. A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples. The minimum required is one per ten, or fraction of ten, environmental samples collected, unless dedicated or disposable sampling equipment is used to collect samples. A trip blank for VOC analysis will be included with each sample cooler shipped.

5.22.3. Field procedures

Sample collection will consist of placing sorbent tube samplers, PUF samplers, and PM 2.5 samplers at upwind and downwind locations for Sites G, H, I, and L. Sample positioning will be located in an unobstructed area, at least two meters from any obstacle to air flow. Sample locations will be selected in the field with the concurrence of the USEPA Region V, or its designee. Since no local power supply is readily available at the sites, gasoline- or diesel-powered generators to supply electricity for the samplers

will be positioned at downwind locations from the sample collection positions. Wind direction and velocity readings will be obtained and recorded.

Sample collection protocols will follow instruction identified in methods TO-1, TO-4, TO-9, and TO-13 for sample preparation, calibration, collection, laboratory preparation and shipment, and calculations. Sample forms will be those provided in the above-stated methods.

5.22.4. Documentation

A field notebook will be kept for the air sampling. Documentation will consist of filling out the forms identified in Methods TO-1, TO-4, TO-9, and TO-13. At a minimum, the field notebook will include the project name and number, date and time, weather conditions, sampler's name, sample location, sample collection times, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site. Notation of USEPA Region V acceptance of sampling locations will be included in the field notebook.

5.23. Pilot test sampling

5.23.1. Rationale/design

Treatability pilot tests will be conducted on wastes and sediments in order to identify any characteristics of these materials that would prevent their treatment using off-site incineration or on-site thermal desorption.

Stabilization treatability pilot tests will be conducted to evaluate the efficacy of stabilization technologies to reduce metals and/or organics leaching.

Leachate treatability pilot testing will be conducted to evaluate the appropriate combination of physical/chemical and/or biological treatment processes that are needed to achieve pretreatment requirements for discharge to the American

Bottoms publicly owned treatment works (POTW). Leachate from Sites G and I is considered representative of leachate found in the fill areas.

Off-site waste incineration. One composite organic waste sample will be made from the waste samples collected from the waste characterization borings installed at each fill area (Sites G, H, I, L, and N). Individual aliquots of this sample will be sent to four RCRA/TSCA-permitted, fixed-facility incinerators for waste profiling, material handling characterization, and evaluation of the feasibility of disposing of the waste material by off-site incineration. Current plans call for sending two aliquots to the SafetyKleen facilities at Deer Park, Texas and Coffeyville, Kansas or to a testing location designated by SafetyKleen. SafetyKleen in Coffeyville, Kansas is the only incineration facility permitted to accept dioxin-containing materials from RCRA-listed processes. Two aliquots will be sent to the Waste Management incinerators at Sauget, Illinois and Port Arthur, Texas or to a testing facility designated by Waste Management. These four facilities are the fixed-facility hazardous waste incinerators closest to Sauget Area 1.

On-site waste thermal desorption. One composite organic waste sample will be made from the waste samples collected from the waste characterization borings installed at each fill area (Sites G, H, I, L, and N). Aliquots of this sample will be sent to three RCRA/TSCA-permitted thermal desorption contractors for waste profiling, material handling characterization, and evaluation of the feasibility of treating the waste material by thermal desorption. Consolidations and bankruptcies in the environmental services market make it unclear who has mobile thermal desorption equipment permitted to handle PCBs and dioxin. In the past, Canonie, McLaren/Hart, SRS and Weston had thermal desorbers designed to operate in a low-oxygen or oxygen-free mode. Research will be conducted to evaluate who is still in the pyrolitic thermal desorption business and who has a nation-wide permit to handle PCB and dioxin-containing materials. Contractors will be identified to USEPA Region V 30 days before the pilot test samples are shipped.

On-site sediment thermal desorption. Sediment samples will be collected every 200 ft in Creek Segment B and at ten locations in Site M to create one composite sediment sample to be used in the sediment on-site thermal desorption pilot treatability testing. Aliquots of this sample will be sent to three RCRA/TSCA-permitted thermal desorption contractors for waste profiling, material handling characterization, and evaluation of the feasibility of treating the waste material by thermal desorption. Consolidations and bankruptcies in the environmental services market make it unclear who has mobile thermal desorption equipment permitted to handle PCBs and dioxin. In the past, Canonie, McLaren/Hart, SRS and Weston had thermal desorbers

designed to operate in a low-oxygen or oxygen-free mode. Research will be conducted to evaluate who is still in the pyrolitic thermal desorption business and who has a nation-wide permit to handle PCB and dioxin-containing materials. Contractors will be identified to USEPA 30 days before the pilot test samples are shipped.

Sediment stabilization. One sediment sample will be collected at the sampling station with the highest detected organic concentration, and one sediment sample will be collected the sampling station with the highest detected metal concentration. Stabilization mix testing treatability pilot tests will be conducted on the two samples to evaluate stabilant mixes that will: 1) solidify sediments to pass the paint filter test, 2) solidify sediments to a bearing capacity of 2000 pounds per square foot, and/or 3) reduce metals or organics leaching. Stabilization mix testing will be done by Kiber Environmental Services, Atlanta, Georgia.

Leachate treatment. Leachate treatability pilot tests will be conducted on samples collected from Sites G and I to evaluate if pretreatment limits can be achieved prior to discharge to the American Bottoms POTW. One leachate sample will be collected from Site I, and one leachate sample will be collected from Site G using the 2-inch diameter well installed at each of these fill areas as part of the Waste Characterization Sampling Plan. As directed by USACE, these wells will be stressed so that a representative leachate sample can be collected. Pumping will be limited by constraints imposed by leachate storage and disposal requirements. Pilot treatability testing will be conducted by the ADVENT Group, Brentwood, Tennessee.

5.23.2. Field procedures

Fill area. The borings will be advanced using conventional hollow stem auger drilling methods. Samples will be collected using a 5-ft continuous sampler. The 5-ft samples will be split and placed into sealable 5-gal buckets for shipment to treatment facilities. This procedure will be repeated for the depth of the boring (approximately forty feet).

Sediment thermal desorption. Creek sediment samples will be collected following procedures outlined in section 5.20.1. Samples will be composited into a sealable 5-gal bucket.

Sediment stabilization. Sediment samples will be collected following the procedures outlined in section 5.20.1. Kiber Environmental Services will be contacted to establish sample quantity requirements.

Leachate sample. Leachate samples will be collected generally following procedures outlined in section 5.7.3. Wells will be pumped at a rate that allows continuous discharge without drying up the well, and sufficient volume will be pumped to enable water from at least 1 ft away from the filter pack to be drawn into the well before a sample is collected. For an 8-inch diameter borehole, a 2-ft long screen, and a porosity of 0.3, this volume is approximately 25 gal of leachate. The ADVENT Group will be contacted to establish sample quantity and container requirements.

5.23.4. Documentation

A field notebook will be kept for the pilot test sampling activity. At a minimum, the field notebook will include the project name and number, date and time, weather conditions, sampler's name, sample location, limiting field conditions, problems encountered, subcontractor personnel on-site, USEPA Region V personnel on-site, and other personnel on-site.

6. Field operations documentation

The field sampling team will maintain a set of field notebooks. Forms that will be used include: chain-of-custody, test boring log, and ground water sampling log. The appendices contain copies of these forms.

The field notebooks will contain tabulated results of field measurements and documentation of field instrument calibration activities. The field notebooks will also record the following:

- Personnel conducting the site activities, their arrival and departure times, and their destination at the site
- Incidents and unusual activities that occur on the site such as, but not limited to, accidents, breaches of security, injuries, equipment failures, and weather related problems
- Changes to the FSP and the HASP
- Daily information such as:

    - Work accomplished and the current site status
    - Equipment calibrations, repairs and results.
    - Site work zones.

In the field sampler's individual bound field notebook, samplers will note, with permanent ink, meteorological data, equipment employed for sample collection, calculations, information regarding collection of QA/QC samples, and any observations. All entries will be signed and dated, and any entry which is to be deleted will have a single cross out which is signed and dated. The following sampling-related information will be recorded in the field notebook by the field sampling team:

- Project name and number
- Sample number
- Sampling location
- Required analysis
- Date and time of sample collection
- Type and matrix of sample
- Sampling technique
- Preservative used, if applicable

- Sampling conditions
- Observations
- Initials of the sampler.

Field data documentation procedures will be minimal in scope. Only direct reading instrumentation will be employed in the field. The use of pH, conductivity, and turbidity meters; a photoionization detector (PID); a real time aerosol monitor (RAM); and thermometers will generate some measurements directly read from the meters following calibration by the respective manufacturer's recommendations. Such data will be written into field notebooks immediately after measurements are taken. If errors are made, results will be legibly crossed out, initialed, and dated by the field member, and corrected in a space adjacent to the original entry. Later, when the results forms are filled out, the O'Brien & Gere Field Leader will proof the forms to assess whether transcription errors have been made.

Photographic records will be developed through the use of digital photographs showing pre-sampling and post-sampling conditions at each site and of the test trenches.

6.1. Sample documentation

6.1.1. Sample identification system

The sample identification system will involve the following:

- Soil gas survey data will be labeled SG-G-1 where "SG" denotes soil gas survey, "G" is the site designation, and "1" denotes a sequential sample number.

- Waste samples will be labeled WASTE-G-___FT where "WASTE" denotes a waste sample, "G" is the site designation, and "___FT" indicates sample depth, which is filled in by the sampler.

- Fill area and upgradient ground water samples will be labeled using the well name (*e.g.*, EEG-107)

- Alluvial aquifer samples will be labeled AA-I-S1-___FT where "AA" denotes an alluvial aquifer sample, "I" is the site designation, "S1" is the sequentially numbered sampling station, and "___FT" indicates sample depth, which is filled in by the sampler.

- Bedrock ground water samples will be labeled BR-1 and BR-2 where "BR" denotes a bedrock ground water sample and "1" and "2" denote sequential numbers.

- Shallow ground water samples will be labeled SGW-S1-___FT where "SGW" denotes a shallow ground water sample, "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Time series ground water samples will be labeled TS-S1-___HR where "TS" denotes a time series sample, "S1" is the sequentially numbered sampling location, and "___HR" indicates sample time, which is filled in by the sampler.

- Domestic well samples will be labeled DW-ABCD-1 where "DW" denotes a domestic well sample, "ABCD" denotes the first four letters of the well owner's last name, and "1" denotes a sequential sample number.

- Undeveloped area soil samples will be labeled UAS-T1-S1-___FT where "UAS" denotes an undeveloped area soil sample, "T1" is the transect number, "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Developed area soil samples will be labeled DAS-T1-S1-___FT where "DAS" denotes a developed area soil sample, "T1" is the transect number "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Background soil samples collected near wells will be labeled BS-EE20-___FT where "BS" denotes a background soil sample, "EE20" is the well location adjacent to the soil sample, and "___FT" indicated sample depth, which is filled in by the sampler.

- Undeveloped area sediment samples will be labeled BSSED-CSA-S1-___FT where "BSSED" denotes a broad-scan sediment sample, "CSA"

designates Dead Creek sector, "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Developed area sediment samples will be labeled FASED-CSA-S1-___FT where "FASED" denotes a focused analysis sediment sample, "CSA" designates Dead Creek sector, "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Borrow Pit Lake sediment samples will be labeled "BPLSED-S1-___FT where "BPLSED" denotes a sediment sample from Borrow Pit Lake, "S1" is the sequentially numbered sampling location and "___FT" indicates sample depth, which is filled in by the sampler.

- Dead Creek sediment samples will be labeled SED-CSA-S1-___FT where "SED" denotes a sediment sample, "CSA" designates the Dead Creek sector, "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Surface water samples will be labeled SW-CSA-S1 or SW-BPL-S1, where "SW" denotes a surface water sample, "CSA" or "BPL" designate Dead Creek sector or Borrow Pit Lake, respectively,, and "S1" is the sequentially numbered sampling location.

- Air samples will be labeled AIR-V-1, AIR-S-1, or AIR-M-1 where "AIR" denotes an air sample, "V", "S", or "M" designate a VOC, SVOC, or metals sample, respectively, and "1" denotes a sequential sample number.

- Incineration pilot test samples will be labeled WI-G-1 where "WI" denotes a waste sample for incineration testing, "G" is the site designation, and "1" denotes a sequential sampling number.

- Waste thermal desorption pilot test samples will be labeled WTD-G-1 where "WTD" denotes a waste sample for thermal desorption testing, "G" is the site designation, and "1" denotes a sequential sample number.

- Sediment thermal desorption pilot test samples will be labeled STD-CSB-1 and STD-M-1 where "STD" denotes a sediment sample for thermal

desorption testing, "CSB" or "M" designates Dead Creek Sector B or Site M, respectively, and "1" denotes a sequential sample number.

- Sediment stabilization pilot test samples will be labeled SS-S1-1 where "SS" denotes a sediment sample for stabilization testing, "S1" is the sequentially numbered sampling station, and "1" denotes a sequential sample number.

- Leachate pilot test samples will be labeled LEACH-I-1 where "LEACH" denotes a leachate sample for testing, "I" is the site designation, and "1" denotes a sequential sample number.

- "MS/MSD" or "DUP" at the end of a sample identification will indicate a matrix spike/matrix spike duplicate or a duplicate sample, respectively.

6.1.2. Sample labels

For proper identification in the field and proper tracking by the analytical laboratory, samples will be labeled in a clear and consistent fashion. Sample labels will be waterproof, or sample containers will be sealed in plastic bags. Field personnel will maintain a sampling log sheet containing information sufficient to allow reconstruction of the sample collection and handling procedures at a later time.

A completed sample tag and sample label will each be attached to each investigative or QC sample. The following will be recorded with permanent ink on sample tags and labels by the field sampling team:

- Project name and number
- Sample number identification
- Initials of sampler
- Sampling location (if not already encoded in the sample number)
- Required analysis
- Date and time of sample collection
- Space for laboratory sample number (only on the sample tag).
- Preservative used, if applicable.

6.1.3. Chain-of-custody records

Chain-of-custody procedures will be instituted and followed throughout the sampling activities. Samples are physical evidence and will be handled

according to strict chain-of-custody protocols. The field sampler is personally responsible for the care and custody of the sample until transferred. For proper identification in the field and proper tracking by the analytical laboratory, samples will be labeled in a clear and consistent fashion.

The following information will be recorded on the chain-of-custody by the field sampling team:

- Project name and number
- Sample description/location
- Required analysis
- Date and time of sample collection
- Type and matrix of sample
- Number of sample containers
- Analysis requested/comments
- Sampler signature/date/time.
- Air bill number.

The laboratory will assign a number for each sample upon receipt. That sample number will be placed on the sample tag and sample label. Both tag and label will be attached to the sample container.

A chain-of-custody document providing all information, signatures, dates, and other information, as required on the example chain-of-custody form in Appendix A, will be completed by the field sampler and provided for each sample cooler. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the chain-of-custody. The field sampler will sign the chain-of-custody form when relinquishing custody, make a copy to keep with the field notebook, and include the original form in an air-tight plastic bag in the sample cooler with the associated samples.

6.2. Field analytical records

Field analytical records for the Support Sampling Project will consist of gas chromatograms from the field gas chromatograph used in the soil gas survey,

and field notebook entries for field instruments. Chromatograms will be taped into an analytical notebook. In addition to information printed on the chromatograms, field notes will be added as appropriate. Information detailed on each chromatogram will include:

- Sample number identification
- Initials of sampler
- Sampling location (if not already encoded in the sample number)

- Required analysis
- Date and time of sample collection
- Date and time of analysis
- Instrument name
- Column and detector type
- Carrier gas and flowrate
- Backflush time
- Injection volume
- Gain setting.

Only direct reading instrumentation will be employed in the field. The use of pH, conductivity, and turbidity meters, a photoionization detector (PID), a real time aerosol monitor (RAM), and thermometers will generate some measurements directly read from the meters following calibration by the respective manufacturer's recommendations. Such data will be written into field notebooks immediately after measurements are taken. Calibration records will also be recorded in the notebooks.

6.3. Data management and retention

The field data and documentation as described in this section will become a part of the final evidence file. The final evidence file will be the central repository for all documents which constitute evidence relevant to sampling and analysis activities as described in this FSP and the QAPP. O'Brien & Gere is the custodian of the evidence file and maintains the contents of evidence files for the site, including all relevant records, reported, logs, field notebooks, pictures, subcontractor reports, data reviews, and the database management system.

Upon completion of the analyses, the project O'Brien & Gere QAO will begin assimilating the field and laboratory notes. In this way, the file for the samples

will be generated. The final file for the sample will be stored at O'Brien & Gere and will consist of the following:

- Laboratory data packages, including summary and raw data from the analysis of environmental and QC samples, chromatograms, mass spectra, calibration data, work sheets, and sample preparation notebooks
- Chain-of-custody records
- Data validation reports.

The following documentation will supplement the chain-of-custody records:

- Field notebooks and data
- Field collection report
- Photographs and drawings
- Progress and QA reports
- Contractor and subcontractor reports
- Correspondence.

The evidence file must be maintained in a secured, limited access area until all submittals for the project have been reviewed and approved, and for a minimum of six years past the submittal date of the final report.

7. Personal protective equipment

Personal protective equipment (PPE) requirements for each level of protection for O'Brien & Gere personnel are described in the HASP prepared for these field activities.

7.1. Protective equipment selection

Initial levels of PPE will be as shown in the following table

Activity	Level B	Level C	Modified Level D	Level D
Trenching		Observation		
Soil Gas Sampling		Initial		
Magnetometer Survey			Initial	
Installation of soil borings and collection of cuttings		Initial		
Ground water sampling at existing wells		Initial		
Installation and sampling of ground water wells		Initial		
Domestic Water Sampling				Initial
Surface and subsurface soil sampling		Area G	Initial	
Surface water and sediment sampling			Initial	
Air sampling				Initial

8. Sample packaging and shipping

A completed sample tag and sample label will each be attached to each investigative or QC sample and the sample placed in a shipping container. Information to be recorded on sample tags and labels is described in section 6.1.2. Information to be recorded on chain-of-custody forms is described in section 6.1.3. The sample identification system used in the field is described in section 6.1.1.

Sampling containers will be packed in styrofoam sheets and put in plastic bags to help prevent breakage and cross-contamination. Samples will be shipped in coolers, each containing a chain-of-custody form and ice and ice packs to maintain inside temperature at approximately 4 °C. Sample coolers will then be sealed between the lid and sides of the cooler with a custody seal prior to shipment. The custody seal will be an adhesive-backed tape that easily rips if it is disturbed. Samples will be shipped to the laboratory by common overnight carrier or will delivered by O'Brien & Gere. The field sampling team will send sample coolers to Savannah Labs. For samples collected for dioxin and dibenzofuran analysis, samples will be sent to Triangle Labs. Samples will not be sent to another laboratory without the permission of USEPA Region V. Sample transportation will comply with U.S. Department of Transportation and ICAO/IATA (1999) regulations. Special sampling packing provisions will be made for samples requiring additional protection.

Samples will remain in the custody of the sampler until transfer of custody is completed. Transfer consists of:

- Delivery of samples to the laboratory sample custodian
- Signature of the laboratory sample custodian on the chain-of-custody document as receiving the samples and signature of sampler as relinquishing the samples.

If a carrier is used to take samples between the sampler and the laboratory, a copy of the air bill must be attached to the chain-of-custody to maintain proof of custody.

9. Investigation-derived wastes

Sampling activities will occur in widely-separated locations. Therefore, personnel and equipment decontamination will be accomplished at each sampling area using temporary facilities. Chapter 8 of the HASP describes personnel and monitoring equipment decontamination procedures and supplies. PPE, disposable sampling equipment, cuttings, purge waters, and field decontamination wastes will be collected at the point of generation and stored in temporary containers. PPE, solids, and liquids will be consolidated in separate bulk containers at a central area. The sampling procedures have been developed to minimize the quantity of waste generated. Additional activity-specific information on disposal of investigation-derived wastes is contained in Chapter 5 of this FSP.

10. Field assessment/inspection

The performance audit is an independent check to evaluate the quality of data being generated. The system audit is an on-site review and evaluation of the quality control practices, sampling procedures, and documentation procedures.

At the discretion of the O'Brien & Gere PM, performance and system audits of field activities will be conducted to verify that sampling and analyses are performed in accordance with the procedures established in this FSP and the QAPP. The audits of field activities include two independent parts: internal and external audits.

The internal audits will be performed by the O'Brien & Gere QAO. The external audits will be performed by USEPA Region V.

10.1. Field performance and system audits

10.1.1. Internal field audits

Internal field audit responsibilities. Internal audits of field activities including sampling and field measurements will be conducted by the O'Brien & Gere QAO.

Internal field audit frequency. These audits will verify that all established procedures are being followed. Internal field audits will be conducted at least once at the beginning of the site sample collection activities and annually thereafter.

Internal field audit procedures. The audits will include examination of field sampling records, field instrumentation operating records, sample collection, handling and packaging in compliance with the established procedures, maintenance of QA procedures, chain-of-custody, and other elements of the field program. Follow up audits will be conducted to correct deficiencies and to verify that QA procedures are maintained throughout the project. The

audits will involve review of field measurement records, instrumentation calibration records, and sample documentation. The areas of concern in a field audit include:

- Sampling procedures
- Decontamination of sampling equipment, if applicable
- Chain-of-custody procedures
- Standard operating procedures
- Proper documentation in field notebooks.
- Subcontractor procedures.

10.1.2. External field audits

External field audit responsibilities. External field audits may be conducted by USEPA Region V.

External field audit frequency. External field audits may be conducted at any time during the field operations. These audits may or may not be announced and are at the discretion of USEPA Region V.

Overview of the external field audit process. External field audits will be conducted according to the field activity information presented in this FSP and the QAPP.

11. Corrective action

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out-of-control performance which can affect data quality. Corrective action can occur during field activities, laboratory analyses, data validation, and data assessment. Corrective action proposed and implemented will be documented in the regular quality assurance reports to management. Corrective action should only be implemented after approval by the O'Brien & Gere PM or the O'Brien & Gere Field Leader. If immediate corrective action is required, approvals secured by telephone from the Project Manager should be documented in an additional memorandum.

For noncompliance problems, a formal corrective action program will be developed and implemented at the time the problem is identified. The person who identifies the problem will be responsible for notifying the O'Brien & Gere PM, who in turn will notify USEPA Region V. Implementation of corrective action will be confirmed in writing through the same channels. Nonconformance with the established quality control procedures in the QAPP or FSP will be identified and corrected in accordance with the QAPP. USEPA Region V will issue a nonconformance report for each nonconformance condition.

11.1. Field corrective action

Corrective action in the field can be needed when the sample network is changed (*i.e.*, more or less samples, sampling location changes, and related modifications) or sampling procedures and/or field analytical procedures require modification due to unexpected conditions. Technical staff and project personnel will be responsible for reporting all suspected technical or QA nonconformances or suspected deficiencies of any activity or issued document by reporting the situation to the O'Brien & Gere Field Leader. The O'Brien & Gere Field Leader will be responsible for assessing the suspected problems in consultation with the O'Brien & Gere PM on making a decision based on the potential for the situation to impact the quality of the data. If it is decided

the situation requires a reportable nonconformance requiring corrective action, a nonconformance report will be initiated by the O'Brien & Gere PM.

The O'Brien & Gere PM will be responsible for verifying corrective actions for nonconformance are initiated by:

- Evaluating reported nonconformances
- Controlling additional work on nonconforming items
- Identifying disposition or action to be taken
- Maintaining a log of nonconformances
- Reviewing nonconformance reports and corrective actions taken
- Verifying nonconformance reports are included in the final site documentation in project files

If appropriate, the O'Brien & Gere Field Leader will verify no additional work dependent on the nonconforming activity is performed until the corrective actions are completed. Corrective action for field measurements may include:

- Repeat the measurement to check the error
- Check for proper adjustments for ambient conditions such as temperature
- Check the batteries
- Re-calibration
- Check the calibration
- Replace the instrument or measurement devices
- Stop work (if necessary).

The O'Brien & Gere Field Leader is responsible for site activities. In this role, the O'Brien & Gere Field Leader at times is required to adjust the site programs to accommodate site-specific needs. When it becomes necessary to modify a program, the responsible person notifies the O'Brien & Gere Field Leader of the anticipated change and implements the necessary changes after obtaining the approval of the O'Brien & Gere Field Leader. The change in the program will be documented on the field change request (FCR) that will be signed by the initiators and the O'Brien & Gere Field Leader. The FCR for each document will be numbered serially as required. The FCR will be attached to the file copy of the affected document. The O'Brien & Gere Field Leader must approve the change in writing or verbally prior to field implementation, if feasible. If unacceptable, the action taken during the period of deviation will be evaluated in order to evaluate the significance of any departure from established program practices and action taken.

The O'Brien & Gere Field Leader is responsible for controlling, tracking, and implementing identified changes. Reports on changes will be distributed to affected parties, which includes USEPA Region V.

Corrective action resulting from internal field audits will be implemented immediately if data may be adversely affected due to unapproved or improper use of approved methods. The O'Brien & Gere QAO will identify deficiencies and recommend corrective action to the O'Brien & Gere PM. Implementation of corrective actions will be performed by the O'Brien & Gere Field Leader and the field team. Corrective action will be documented in the quality assurance report to the project management.

Corrective actions will be implemented and documented in the field notebook. No staff member will initiate corrective action without prior communication of findings through the proper channels. If corrective actions are insufficient, work may be stopped by USEPA Region V.

The O'Brien & Gere QAO and Laboratory QAO may identify the need for corrective action during either the data validation or data assessment. Potential types of corrective action may include resampling by the field team or reinjection or reanalysis of samples by the laboratory.

These actions are dependent upon the ability to mobilize the field team or whether the data to be collected is necessary to meet the required quality assurance objectives. When the O'Brien & Gere QAO or Laboratory QAO identifies a corrective action situation, it is the O'Brien & Gere PM who will be responsible for approving the implementation of corrective action, including resampling, during data assessment. Corrective actions of this type will be documented by the O'Brien & Gere QAO and the Laboratory QAO.

References

Ecology and Environment, Inc. 1988. *Expanded Site Investigation, Dead Creek Project Sites at Cahokia/Sauget, Illinois.*

Ecology and Environment, Inc. 1997. *Preliminary Ecological Risk Assessment for Sauget Area 1, Creek Segment F, Sauget, St. Clair County, Illinois.*

Ecology and Environment, Inc. 1998. *Sauget Area 1 Data Tables/Maps.* USEPA Alternative Remedial Contracting Strategy (ARCS) Contract No. 68-W8-0086. Work Assignment No. 47-5N60.

Geraghty and Miller. 1992. *Site Investigation for Dead Creek Segment B and Sites L and M, Sauget-Cahokia, Illinois.*

O'Brien & Gere Engineers, Inc. 1999. *Health and Safety Plan, Sauget Area 1 Support Sampling Project, Sauget and Cahokia, Illinois, Volume 2.*

O'Brien & Gere Engineers, Inc. 1999. *Quality Assurance Project Plan, Sauget Area 1 Support Sampling Project, Sauget and Cahokia, Illinois, Volume 2.*

Solutia Inc. 1999. *EE/CA and RI/FS Support Sampling Plan.*

U.S. Environmental Protection Agency (USEPA). 1988. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA/600/4-89/017, June 1988, Research Triangle Park, NC.

U.S. Environmental Protection Agency (USEPA). 1996. *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels, Draft.* EPA-821-R-96-011.

U.S. Environmental Protection Agency (USEPA). 1999. *Final Administrative Order by Consent, Sauget Area 1 Site, Sauget and Cahokia, Illinois.*

TABLES

Table Fill Area Soil Gas Survey - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike / Matrix Spike Duplicates or Spike Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size,type)	Preservation	Holding Time	Total Analyses
G	Soil Gas	VOC-Field GC 3810 [1]	6 min 18 max	N/A	N/A	N/A	N/A	N/A	N/A	N/A	min 6 max 18
H	Soil Gas	VOC-Field GC 3810 [1]	8 min 20 max	N/A	N/A	N/A	N/A	N/A	N/A	N/A	min 8 max 20
I	Soil Gas	VOC-Field GC 3810 [1]	12 min 24 max	N/A	N/A	N/A	N/A	N/A	N/A	N/A	min 12 max 24
L	Soil Gas	VOC-Field GC 3810 [1]	1 min 13 max	N/A	N/A	N/A	N/A	N/A	N/A	N/A	min 1 max 13
N	Soil Gas	VOC-Field GC 3810 [1]	2 min 14 max	N/A	N/A	N/A	N/A	N/A	N/A	N/A	min 2 max 14
Total Samples			29 min 89 max	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	min 29 max 89

[1] Static headspace analysis, closely parallels USEPA Method 3810

Table 2 Fill Area Waste Sampling Borings - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time to 1311 extract/ to extraction/ to analysis	Total Analyses
G	Waste	Ignitability -1010/1020A	4		0	0	0	1 - 100 ml plastic	4°C	As soon as possible	4
		Corrosivity-1110	4		0	0	0	container			4
		Reactivity-9014	4		0	0	0				4
		VOC-1311/5035/8260B	4	1	0	0	4	4-25 gm En-Core[1]	4°C	48 Hours/14/14days	9
		SVOC-1311/8270C	4	1	0	0	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/7/40 days	5
		Metals-1311/6010B	4	1	0	0	0	1-4 oz widemouth	4°C	180/---/180 days	5
		Mercury-1311/7471A	4	1	0	0	0	polyethylene or glass		28/---/28 days	5
		Cyanide-9010B	4	1	0	0	0	1-4oz wide mouth amber glass with Teflon lined lid	4°C	14 days	5
		PCBS - 680	4	1	0	0	0	1-500 ml, wide mouth glass with Teflon lined lid	4°C	---/14/40 days	5
		Pesticides-1311/8081A	4	1	0	0	0	1-250 ml, wide mouth	4°C	14/14/40 days	5
		Herbicides-1311/8151A	4	1	0	0	0	glass with Teflon lined lid			5
		Dioxin-1311/8280A	4	1	0	0	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	5
H	Waste	Ignitability -1010/1020A	4	0	0	0	0	1-100 ml plastic	4°C	As soon as possible	4
		Corrosivity-1110	4	0	0	0	0	container			4
		Reactivity-9014	4	0	0	0	0				4
		VOC-1311/5035/8260B	4	1	1	0	4	4-25 gm En-Core[1]	4°C	48 Hours/14/14days	10
		SVOC-1311/8270C	4	1	1	0	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/7/40 days	6
		Metals-1311/6010B	4	1	1	0	0	1-4 oz widemouth	4°C	180/---/180 days	6
		Mercury-1311/7471A	4	1	1	0	0	polyethylene or glass		28/---/28 days	6
		Cyanide-9010B	4	1	1	0	0	1-4oz wide mouth amber glass with Teflon lined lid	4°C	14 days	6
		PCBS - 680	4	1	1	0	0	1-500 ml, wide mouth glass with Teflon lined lid	4°C	---/14/40 days	6
		Pesticides-1311/8081A	4	1	1	0	0	1-250 ml, wide mouth	4°C	14/14/40 days	6
		Herbicides-1311/8151A	4	1	1	0	0	glass with Teflon lined lid			6
		Dioxin-1311/8280A	4	1	1	0	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	6

Table 2 Fill Area Waste Sampling Borings - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time to 1311 extract/ to extraction/ to analysis	Total Analyses
I	Waste	Ignitability -1010/1020A	4	0	0	0	0	1-100 ml plastic	4°C	As soon as possible	4
		Corrosivity-1110	4	0	0	0	0	container			4
		Reactivity-9014	4	0	0	0	0				4
		VOC-1311/5035/8260B	4	1	0	1	4	4-25 gm En-Core[1]	4°C	48 Hours/14/14days	10
		SVOC-1311/8270C	4	1	0	1	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/7/40 days	6
		Metals-1311/6010B	4	1	0	1	0	1-4 oz widemouth	4°C	180/---/180 days	6
		Mercury-1311/7471A	4	1	0	1	0	polyethylene or glass		28/---/28 days	6
		Cyanide-9010B	4	1	0	1	0	1-4oz wide mouth amber glass with Teflon lined lid	4°C	14 days	6
		PCBS - 680	4	1	0	1	0	1-500 ml, wide mouth glass with Teflon lined lid	4°C	---/14/40 days	5
		Pesticides-1311/8081A	4	1	0	1	0	1-250 ml, wide mouth	4°C	14/14/40 days	5
		Herbicides-1311/8151A	4	1	0	1	0	glass with Teflon lined lid			5
		Dioxin-1311/8280A	4	1	0	1	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	6
L	Waste	Ignitability -1010/1020A	4		0	0	0	1-100 ml plastic	4°C	As soon as possible	4
		Corrosivity-1110	4		0	0	0	container			4
		Reactivity-9014	4		0	0	0				4
		VOC-1311/5035/8260B	4	1	1	0	4	4-25 gm En-Core[1]	4°C	48 Hours/14/14days	10
		SVOC-1311/8270C	4	1	1	0	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/7/40 days	6
		Metals-1311/6010B	4	1	1	0	0	1-4 oz widemouth	4°C	180/---/180 days	6
		Mercury-1311/7471A	4	1	1	0	0	polyethylene or glass		28/---/28 days	6
		Cyanide-9010B	4	1	1	0	0	1-4oz wide mouth amber glass with Teflon lined lid	4°C	14 days	6
		PCBS - 680	4	1	1	0	0	1-500 ml, wide mouth glass with Teflon lined lid	4°C	---/14/40 days	5
		Pesticides-1311/8081A	4	1	1	0	0	1-250 ml, wide mouth	4°C	14/14/40 days	5
		Herbicides-1311/8151A	4	1	1	0	0	glass with Teflon lined lid			5
		Dioxin-1311/8280A	4	1	1	0	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	6

Table 2 Fill Area Waste Sampling Borings - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time to 1311 extract/ to extraction/ to analysis	Total Analyses
N	Waste	Ignitability -1010/1020A	4	0	0	0	0	1-100 ml plastic	4°C	As soon as possible	4
		Corrosivity-1110	4	0	0	0	0	container			4
		Reactivity-9014	4	0	0	0	0				4
		VOC-1311/5035/8260B	4	1	0	1	4	4-25 gm En-Core[1]	4°C	48 Hours/14/14days	10
		SVOC-1311/8270C	4	1	0	1	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/7/40 days	6
		Metals-1311/6010B	4	1	0	1	0	1-4 oz widemouth	4°C	180/---/180 days	6
		Mercury-1311/7471A	4	1	0	1	0	polyethylene or glass		28/---/28 days	6
		Cyanide-9010B	4	1	0	1	0	1-4oz wide mouth amber glass with Teflon lined lid	4°C	14 days	6
		PCBS - 680	4	1	0	1	0	1-500 ml, wide mouth glass with Teflon lined lid	4°C	---/14/40 days	5
		Pesticides-1311/8081A	4	1	0	1	0	1-250 ml, wide mouth	4°C	14/14/40 days	5
		Herbicides-1311/8151A	4	1	0	1	0	glass with Teflon lined lid			5
		Dioxin-1311/8280A	4	1	0	1	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	6
M	Sediment	Ignitability -1010/1020A	4	1	0	0	0	1-100 ml plastic	4°C	As soon as possible	4
		Corrosivity-1110	4	1	0	0	0	container			4
		Reactivity-9014	4	1	0	0	0				4
		VOC-1311/5035/8260B	4	1	1	0	4	4-25 gm En-Core[1]	4°C	48 Hours/14/14days	10
		SVOC-1311/8270C	4	1	1	0	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/7/40 days	6
		Metals-1311/6010B	4	1	1	0	0	1-4 oz widemouth	4°C	180/---/180 days	6
		Mercury-1311/7471A	4	1	1	0	0	polyethylene or glass		28/---/28 days	6
		Cyanide-9010B	4	1	1	0	0	1-4oz wide mouth amber glass with Teflon lined lid	4°C	14 days	6
		PCBS - 680	4	1	1	0	0	1-500 ml, wide mouth glass with Teflon lined lid	4°C	---/14/40 days	5
		Pesticides-1311/8081A	4	1	1	0	0	1-250 ml, wide mouth	4°C	14/14/40 days	5
		Herbicides-1311/8151A	4	1	1	0	0	glass with Teflon lined lid			5
		Dioxin-1311/8280A	4	1	1	0	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	6
Total Samples			288	54	27	18	24				411

[1] or sample will be preserved in accordance with USEPA Method 5035

Table 3 Fill A 'Waste Sampling, Surface Soils - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
G	Soil	Ignitability -1010/1020A	4	0	0	0	0	1-250 ml glass	4°C	As soon as possible	4
		Corrosivity-1110	4	0	0	0	0	container with Teflon			4
		Reactivity-9014	4	0	0	0	0	lined lid			4
		VOC-5035/8260B	4	1	1	0	4	3- 5 gm En-Core[1]	4°C	48 hrs /14 days	10
		SVOC-8270C	4	1	1	0	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/40 days	6
		Metals-6010B	4	1	1	0	0	1-4 oz widemouth	4°C	180 days	6
		Mercury-7471A	4	1	1	0	0	polyethylene or glass		28 days	6
		Cyanide-9010B	4	1	1	0	0	1-4oz wide mouth amber glass with Teflon lined lid	4°C	14 days	6
		PCB - 680	4	1	1	0	0	1 - 500 ml wide mouth glass with Teflon lined lid	4°C	14/40 days	6
		Pesticides-8081A	4	1	1	0	0	1 - 250 ml wide mouth	4°C	14/40 days	6
		Herbicides-8151A	4	1	1	0	0	glass with Teflon lined lid			6
		Dioxin - 8280A	4	1	1	0	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	6
H	Soil	Ignitability -1010/1020A	4	0	0	0	0	1-250 ml glass	4°C	As soon as possible	4
		Corrosivity-1110	4	0	0	0	0	container with Teflon			4
		Reactivity-9014	4	0	0	0	0	lined lid			4
		VOC-5035/8260B	4	1	0	1	4	3- 5 gm En-Core[1]	4°C	48 hrs /14 days	10
		SVOC-8270C	4	1	0	1	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/40 days	6
		Metals-6010B	4	1	0	1	0	1-4 oz widemouth	4°C	180 days	6
		Mercury-7471A	4	1	0	1	0	polyethylene or glass		28 days	6
		Cyanide-9010B	4	1	0	1	0	1-4oz wide mouth amber glass with	4°C	14 days	6
		PCB - 680	4	1	0	1	0	1 - 500 ml wide mouth glass with Teflon lined lid	4°C	14/40 days	6
		Pesticides-8081A	4	1	0	1	0	1 - 250 ml wide mouth	4°C	14/40 days	6
		Herbicides-8151A	4	1	0	1	0	glass with Teflon lined lid			6
		Dioxin - 8280A	4	1	0	1	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	6

Table 3 Fill Area Waste Sampling, Surface Soils - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
I	Soil	Ignitability -1010/1020A	4	0	0	0	0	1-250 ml glass	4°C	As soon as possible	4
		Corrosivity-1110	4	0	0	0	0	container with Teflon			4
		Reactivity-9014	4	0	0	0	0	lined lid			4
		VOC-5035/8260B	4	1	1	0	4	3- 5 gm En-Core[1]	4°C	48 hrs /14 days	10
		SVOC-8270C	4	1	1	0	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/40 days	6
		Metals-6010B	4	1	1	0	0	1-4 oz widemouth	4°C	180 days	6
		Mercury-7471A	4	1	1	0	0	polyethylene or glass		28 days	6
		Cyanide-9010B	4	1	1	0	0	1-4oz wide mouth amber glass with	4°C	14 days	6
		PCB - 680	4	1	1	0	0	1 - 500 ml wide mouth	4°C	14/40 days	6
					1	0	0	glass with Teflon lined			
					1	0	0	lid			
		Pesticides-8081A	4	1	1	0	0	1 - 250 ml wide mouth	4°C	14/40 days	6
		Herbicides-8151A	4	1				glass with Teflon lined lid			6
		Dioxin - 8280A	4	1	1	0	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	6
L	Soil	Ignitability -1010/1020A	4	0	0	0	0	1-250 ml glass	4°C	As soon as possible	4
		Corrosivity-1110	4	0	0	0	0	container with Teflon			4
		Reactivity-9014	4	0	0	0	0	lined lid			4
		VOC-5035/8260B	4	1	0	0	4	3- 5 gm En-Core[1]	4°C	48 hrs /14 days	9
		SVOC-8270C	4	1	0	0	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/40 days	5
		Metals-6010B	4	1	0	0	0	1-4 oz widemouth	4°C	180 days	5
		Mercury-7471A	4	1	0	0	0	polyethylene or glass		28 days	5
		Cyanide-9010B	4	1	0	0	0	1-4oz wide mouth amber glass with	4°C	14 days	5
		PCB - 680	4	1	0	0	0	1 - 500 ml wide mouth glass with Teflon lined lid	4°C	14/40 days	5
		Pesticides-8081A	4	1	0	0	0	1 - 250 ml wide mouth	4°C	14/40 days	5
		Herbicides-8151A	4	1	0	0	0	glass with Teflon lined lid			5
		Dioxin - 8280A	4	1	0	0	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	5

Table 3 Fill , Waste Sampling, Surface Soils - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
N	Soil	Ignitability -1010/1020A	4	0	0	0	0	1-250 ml glass	4°C	As soon as possible	4
		Corrosivity-1110	4	0	0	0	0	container with Teflon			4
		Reactivity-9014	4	0	0	0	0	lined lid			4
		VOC-5035/8260B	4	1	0	0	4	3- 5 gm En-Core[1]	4°C	48 hrs /14 days	9
		SVOC-8270C	4	1	0	0	0	1-250 ml wide mouth glass w/Teflon lined lid	4°C	14/40 days	5
		Metals-6010B	4	1	0	0	0	1-4 oz widemouth	4°C	180 days	5
		Mercury-7471A	4	1	0	0	0	polyethylene or glass		28 days	5
		Cyanide-9010B	4	1	0	0	0	1-4oz wide mouth amber glass with	4°C	14 days	5
		PCB - 680	4	1	0	0	0	1 - 500 ml wide mouth glass with Teflon lined lid	4°C	14/40 days	5
		Pesticides-8081A	4	1	0	0	0	1 - 250 ml wide mouth	4°C		5
		Herbicides-8151A	4	1	0	0	0	glass with Teflon lined lid			5
		Dioxin - 8280A	4	1	0	0	0	100 gm in 1-4 oz amber glass jar with Teflon lined lid	4°C	30/45 days	5
Total Samples			240	45	18	9	20				332

[1] or sample will be preserved in accordance with USEPA Method 5035

Note: surface soils samples to be collected at same locations and prior to starting waste sample collection

Table 4. Fill Areas Ground Water Sampling - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/ Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number, size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
G	Ground Water	VOC-8260B	7	2	1	0	7	3-40 ml vials with Teflon lined septum caps	4°C HCL to pH<2	14 days	17
		SVOC-8270C	7	2	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	10
		Metals-6010B	7	2	1	0	0	1-250 or 500 ml poly	HNO_3 to pH<2	180 days	10
		Mercury-7470A	7	2	1	0	0	or fluorocarbon	4°C	28 days	10
		Cyanide-9010B	7	2	1	0	0	1- 250 or 500 ml poly	NaOH to pH>12 4°C	14 days	10
		PCB-680	7	2	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	10
		Pesticides-8081A	7	2	1	0	0	4-1 liter amber glass			10
		Herbicides-8151A	7	2	1	0	0	with Teflon lined screw caps			10
		Dioxin-8290	7	2	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	30/45 days	10
H	Ground Water	VOC-8260B	4	1	0	1	5	3-40 ml vials with Teflon lined septum caps	4°C HCL to pH<2	14 days	11
		SVOC-8270C	4	1	0	1	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	6
		Metals-6010B	4	1	0	1	0	1-250 or 500 ml poly	HNO_3 to pH<2	180 days	6
		Mercury-7470A	4	1	0	1	0	or fluorocarbon	4°C	28 days	6
		Cyanide-9010B	4	1	0	1	0	1- 250 or 500 ml poly	NaOH to pH>12 4°C	14 days	6
		PCB-680	4	1	0	1	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	6
		Pesticides-8081A	4	1	0	1	0	4-1 liter amber glass			6
		Herbicides-8151A	4	1	0	1	0	with Teflon lined screw caps			6
		Dioxin-8290	4	1	0	1	0	2-1 liter amber glass with Teflon lined screw caps	4°C	30/45 days	6

Table 4. Fill Areas Ground Water Sampling - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/ Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number, size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
I	Ground Water	VOC-8260B	4	1	1	0	5	3-40 ml vials with Teflon lined septum caps	4°C HCL to pH<2	14 days	11
		SVOC-8270C	4	1	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	6
		Metals-6010B	4	1	1	0	0	1-250 or 500 ml poly	HNO_3 to pH<2	180 days	6
		Mercury-7470A	4	1	1	0	0	or fluorocarbon	4°C	28 days	6
		Cyanide-9010B	4	1	1	0	0	1- 250 or 500 ml poly	NaOH to pH>12 4°C	14 days	6
		PCB-680	4	1	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	6
		Pesticides-8081A	4	1	1	0	0	4-1 liter amber glass with Teflon lined screw caps			6
		Herbicides-8151A	4	1	1						6
		Dioxin-8290	4	1	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	30/45 days	6
L	Ground Water	VOC-8260B	3	1	0	0	3	3-40 ml vials with Teflon lined septum caps	4°C HCL to pH<2	14 days	7
		SVOC-8270C	3	1	0	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	4
		Metals-6010B	3	1	0	0	0	1-250 or 500 ml poly	HNO_3 to pH<2	180 days	4
		Mercury-7470A	3	1	0	0	0	or fluorocarbon	4°C	28 days	4
		Cyanide-9010B	3	1	0	0	0	1- 250 or 500 ml poly	NaOH to pH>12 4°C	14 days	4
		PCB-680	3	1	0	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	4
		Pesticides-8081A	3	1	0	0	0	4-1 liter amber glass with Teflon lined screw caps			4
		Herbicides-8151A	3	1	0	0	0				4
		Dioxin-8290	3	1	0	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	30/45 days	4

Table 4. Fill Areas Ground Water Sampling - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/ Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number, size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
South of of G	Ground Water	VOC-8260B	1	0	0	0	1	3-40 ml vials with Teflon lined septum caps	4°C HCL to pH<2	14 days	2
		SVOC-8270C	1	0	0	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	1
		Metals-6010B	1	0	0	0	0	1-250 or 500 ml poly	HNO_3 to pH<2	180 days	1
		Mercury-7470A	1	0	0	0	0	or fluorocarbon	4°C	28 days	1
		Cyanide-9010B	1	0	0	0	0	1- 250 or 500 ml poly	NaOH to pH>12 4°C	14 days	1
		PCB-680	1	0	0	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	1
		Pesticides-8081A	1	0	0	0	0	4-1 liter amber glass			1
		Herbicides-8151A	1	0	0	0	0	with Teflon lined screw caps			1
		Dioxin-8290	1	0	0	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	30/45 days	1
Total Samples			171	45	18	9	21				264

Table 5 Fill Area Alluvial Aquifer Ground Water Sampling - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/ Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time Extraction/analysis	Total Analyses
H	Ground Water	VOC-8260B	4	1	1	0	4	3-40 ml glass vials with Teflon lined septum caps	HCL to pH<2 4°C	14 days	10
		SVOC-8270C	4	1	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	6
		Metals-6010B	4	1	1	0	0	1-250 or 500 ml poly	HNO_3 to	180 days	6
		Mercury-7470A	4	1	1	0	0	or fluorocarbon	pH < 2, 4°C	28 days	6
		Cyanide-9010B	4	1	1	0	0	1-250 or 500 ml poly	NaOH to pH >12,4°C	14 days	6
		PCB- 680	4	1	1	0	0	2 -1 liter amber glass with Teflon lined screw cap	4°C	7/40 days	6
		Pesticides-8081A	4	1	1	0	0	4-1 liter amber glass	4°C	7/40 days	6
		Herbicides-8151A	4	1	1	0	0	with Teflon lined screw caps			6
		Dioxin - 8290	4	1	1	0	0	2 - 1 liter amber glas with Teflon lined screw caps	4°C	30/45 days	6
I	Ground Water	VOC-8260B	4	1	0	1	4	3-40 ml glass vials with Teflon lined septum caps	HCL to pH<2 4°C	14 days	10
		SVOC-8270C	4	1	0	1	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	6
		Metals-6010B	4	1	0	1	0	1-250 or 500 ml poly	HNO_3 to	180 days	6
		Mercury-7470A	4	1	0	1	0	or fluorocarbon	pH < 2, 4°C	28 days	6
		Cyanide-9010B	4	1	0	1	0	1-250 or 500 ml poly	NaOH to pH >12,4°C	14 days	6
		PCB- 680	4	1	0	1	0	2-1 liter amber glass with Teflon lined screw cap	4°C	7/40 days	6
		Pesticides-8081A	4	1	0	1	0	4-1 liter amber glass	4°C	7/40 days	6
		Herbicides-8151A	4	1	0	1	0	with Teflon lined screw caps			6
		Dioxin - 8290	4	1	0	1	0	2 - 1 liter amber glas with Teflon lined screw caps	4°C	30/45 days	6
Total Samples			72	18	9	9	8				116

Table 6 Downgradient Alluvial Aquifer Sampling - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmen Samples	Number of Field Blank Equipment Blanks	Number Field Duplicat	Number of Matr Spike/Matrix Sp Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
G,H,L	Ground Water	VOC-8260B	30	6	3	2	30	3-40 ml glass vials with Teflon lined septum caps	HCL to pH<2 4°C	14 days	71
		SVOC-8270C	30	6	3	2	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	41
		Metals-6010B	30	6	3	2	0	1- 250 or 500 ml	HNO3 to	180 days	41
		Mercury-7470A	30	6	3	2	0	poly or fluorocarbon	pH<2, 4°C	28 days	41
		Cyanide-9010B	30	6	3	2	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	41
		PCB - 680	30	6	3	2	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	41
		Pesticides-8081A	30	6	3	2	0	4- 1 liter amber glass	4°C	7/40 days	41
		Herbicides-8151A	30	6	3	2	0	w/Teflon lined screw caps			41
		Dioxin-8290	9	3	1	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45	14
I	Ground Water	VOC-8260B	30	6	3	2	30	3-40 ml glass vials with Teflon lined septum caps	HCL to pH<2 4°C	14 days	71
		SVOC-8270C	30	6	3	2	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	41
		Metals-6010B	30	6	3	2	0	1- 250 or 500 ml	HNO3 to	180 days	41
		Mercury-7470A	30	6	3	2	0	poly or fluorocarbon	pH<2, 4°C	28 days	41
		Cyanide-9010B	30	6	3	2	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	41
		PCB - 680	30	6	3	2	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	41
		Pesticides-8081A	30	6	3	2	0	4- 1 liter amber glass	4°C	7/40 days	41
		Herbicides-8151A	30	6	3	2	0	w/Teflon lined screw caps			41
		Dioxin-8290	9	3	1	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45	14

Table 6 Downgradient Alluvial Aquifer Sampling - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmen Samples	Number of Field Blank Equipment Blanks	Number Field Duplicat	Number of Matr Spike/Matrix Sp Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
SW of G,H,I,L	Ground Water	VOC-8260B	30	6	3	2	30	3-40 ml glass vials with Teflon lined septum caps	HCL to pH<2 4°C	14 days	71
		SVOC-8270C	30	6	3	2	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	41
		Metals-6010B	30	6	3	2	0	1- 250 or 500 ml	HNO3 to	180 days	41
		Mercury-7470A	30	6	3	2	0	poly or fluorocarbon	pH<2, 4°C	28 days	41
		Cyanide-9010B	30	6	3	2	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	41
		PCB - 680	30	6	3	2	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	41
		Pesticides-8081A	30	6	3	2	0	4- 1 liter amber glass	4°C	7/40 days	41
		Herbicides-8151A	30	6	3	2	0	w/Teflon lined screw caps			41
		Dioxin-8290	9	3	1	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45	14
Total Samples			747	153	75	51	90				1116

Table 7 Bedrock Ground Water Sampling - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
G	Ground Water	VOC-8260B	1	1	0	1	1	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	4
		SVOC-8270C	1	1	0	1	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	3
		Metals-6010B	1	1	0	1	0	1- 250 or 500 ml	HNO3 to	180 days	3
		Mercury-7470A	1	1	0	1	0	poly or fluorocarbon	pH<2, 4°C	28 days	3
		Cyanide-9010B	1	1	0	1	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	3
		PCB-680	1	1	1	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	3
		Pesticides-8081A	1	1	1	0	0	4- 1 liter amber glass	4°C	7/40 days	3
		Herbicides-8151A	1	1	1	0	0	w/Teflon lined screw caps			3
		Dioxin -8290	1	1	0	1	0	2 - 1 liter amber glass w/ Teflon lined screw caps	4°C	30/45 days	3
H	Ground Water	VOC-8260B	1	1	1	0	1	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	4
		SVOC-8270C	1	1	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	3
		Metals-6010B	1	1	1	0	0	1- 250 or 500 ml	HNO3 to	180 days	3
		Mercury-7470A	1	1	1	0	0	poly or fluorocarbon	pH<2, 4°C	28 days	3
		Cyanide-9010B	1	1	1	0	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	3
		PCB-680	1	1	1	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	3
		Pesticides-8081A	1	1	1	0	0	4- 1 liter amber glass	4°C	7/40 days	3
		Herbicides-8151A	1	1	1	0	0	w/Teflon lined screw caps			3
		Dioxin -8290	1	1	1	0	0	2 - 1 liter amber glass w/ Teflon lined screw caps	4°C	30/45 days	3

Table 7 Bedrock Ground Water Sampling - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
I	Ground Water	VOC-8260B	1	1	0	0	1	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	3
		SVOC-8270C	1	1	0	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	2
		Metals-6010B	1	1	0	0	0	1- 250 or 500 ml	HNO3 to	180 days	2
		Mercury-7470A	1	1	0	0	0	poly or fluorocarbon	pH<2, 4°C	28 days	2
		Cyanide-9010B	1	1	0	0	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	2
		PCB-8082	1	1	0	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	2
		Pesticides-8081A	1	1	0	0	0	4- 1 liter amber glass			2
		Herbicides-8151A	1	1	0	0	0	w/Teflon lined screw caps			2
		Dioxin -8290	1	1	0	0	0	2 - 1 liter amber glass w/ Teflon lined screw caps	4°C	30/45 days	2
Total Samples			27	27	9	9	3				75

Table 8 Shallow Residential Area Ground Water Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Walnut St	Ground Water	VOC-8260B	3	1	1	0	3	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	8
		SVOC-8270C	3	1	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	5
		Metals-6010B	3	1	1	0	0	1- 250 or 500 ml	HNO3 to	180 days	5
		Mercury-7470A	3	1	1	0	0	poly or fluorocarbon	pH<2, 4°C	28 days	5
		Cyanide-9010B	3	1	1	0	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	5
		PCB -680	3	1	1	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	5
		Pesticides-8081A	3	1	1	0	0	4- 1 liter amber glass	4°C	7/40 days	5
		Herbicides-8151A	3	1	1	0	0	w/Teflon lined screw caps			5
		Dioxin-8290	3	1	1	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45 days	
E. Bank Dead Creek at Judith Lane	Ground Water	VOC-8260B	3	1	0	1	3	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	8
		SVOC-8270C	3	1	0	1	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	5
		Metals-6010B	3	1	0	1	0	1- 250 or 500 ml	HNO3 to	180 days	5
		Mercury-7470A	3	1	0	1	0	poly or fluorocarbon	pH<2, 4°C	28 days	5
		Cyanide-9010B	3	1	0	1	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	5
		PCB - 680	3	1	0	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	5
		Pesticides-8081A	3	1	0	1	0	4- 1 liter amber glass	4°C	7/40 days	5
		Herbicides-8151A	3	1	0	1	0	w/Teflon lined screw caps			5
		Dioxin-8290	3	1	0	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45 days	5
Total Samples			54	18	9	9	6				96

Table 9 *Time Series Ground Water Sampling - Sample and Analysis Summary*

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Walnut St.	Ground Water	VOC-8260B	3	1	1	0	3	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	8
		SVOC-8270C	3	1	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	5
		Metals-6010B	3	1	1	0	0	1- 250 or 500 ml	HNO3 to	180 days	5
		Mercury-7470A	3	1	1	0	0	poly or fluorocarbon	pH<2, 4°C	28 days	5
		Cyanide-9010B	3	1	1	0	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	5
		PCB - 680	3	1	1	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	5
		Pesticides-8081A	3	1	1	0	0	4- 1 liter amber glass	4°C	7/40 days	5
		Herbicides-8151A	3	1	1	0	0	w/Teflon lined screw caps			5
		Dioxin-8290	3	1	1	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45 days	
E. Bank Dead Creek at Judith Lane	Ground Water	VOC-8260B	3	1	0	1	3	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	8
		SVOC-8270C	3	1	0	1	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	5
		Metals-6010B	3	1	0	1	0	1- 250 or 500 ml	HNO3 to	180 days	5
		Mercury-7470A	3	1	0	1	0	poly or fluorocarbon	pH<2, 4°C	28 days	5
		Cyanide-9010B	3	1	0	1	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	5
		PCB - 680	3	1	0	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	5
		Pesticides-8081A	3	1	0	1	0	4- 1 liter amber glass	4°C	7/40 days	5
		Herbicides-8151A	3	1	0	1	0	w/Teflon lined screw caps			5
		Dioxin-8290	3	1	0	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45 days	5
Total Samples			54	18	9	9	6				96

Table 10 Domestic Well Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Walnut St. and Judith Lane	Ground Water	VOC-8260	4	1	1	1	3	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	10
		SVOC-8270	4	1	1	1	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	7
		Metals-6010	4	1	1	1	0	1- 250 or 500 ml	HNO3 to	180 days	7
		Mercury-7470A	4	1	1	1	0	poly or fluorocarbon	pH<2, 4°C	28 days	7
		Cyanide-9010B	4	1	1	1	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	7
		PCB - 680	4	1	1	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	7
		Pesticides-8081A	4	1	1	1	0	4- 1 liter amber glass	4°C	7/40 days	7
		Herbicides-8151A	4	1	1	1	0	w/Teflon lined screw caps			7
		Dioxin-8290	4	1	1	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45 days	7
Total Samples			36	9	9	9	3				66

Table 11 Grain Size Analysis - Sample and Analysis Summary

Site	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
G	Soil	Sieve/ Hygrometer	3	0	0	0	0	1 to 3, 1 liter plastic depending on soil	none	N/A	3
H	Soil	Sieve/ Hygrometer	3	0	0	0	0	1 to 3, 1 liter plastic depending on soil	none	N/A	3
I	Soil	Sieve/ Hygrometer	3	0	0	0	0	1 to 3, 1 liter plastic depending on soil	none	N/A	3
L	Soil	Sieve/ Hygrometer	3	0	0	0	0	1 to 3, 1 liter plastic depending on soil	none	N/A	3
N	Soil	Sieve/ Hygrometer	3	0	0	0	0	1 to 3, 1 liter plastic depending on soil	none	N/A	3
Total Samples			15								15

N/A---not applicable

Table 12 Upgradient Ground Water Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
EE-20	Ground Water	VOC-8260	3	1	1	0	3	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	8
		SVOC-8270	3	1	1	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	5
		Metals-6010	3	1	1	0	0	1- 250 or 500 ml	HNO3 to	180 days	5
		Mercury-7470A	3	1	1	0	0	poly or fluorocarbon	pH<2, 4°C	28 days	5
		Cyanide-9010B	3	1	1	0	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	5
		PCB - 680	3	1	1	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	5
		Pesticides-8081A	3	1	1	0	0	4- 1 liter amber glass	4°C	7/40 days	5
		Herbicides-8151A	3	1	1	0	0	w/Teflon lined screw caps			5
		Dioxin-8290	3	1	1	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45 days	
EE-04	Ground Water	VOC-8260	3	1	0	1	3	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	8
		SVOC-8270	3	1	0	1	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	5
		Metals-6010	3	1	0	1	0	1- 250 or 500 ml	HNO3 to	180 days	5
		Mercury-7470A	3	1	0	1	0	poly or fluorocarbon	pH<2, 4°C	28 days	5
		Cyanide-9010B	3	1	0	1	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	5
		PCB - 680	3	1	0	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	5
		Pesticides-8081A	3	1	0	1	0	4- 1 liter amber glass	4°C	7/40 days	5
		Herbicides-8151A	3	1	0	1	0	w/Teflon lined screw caps			5
		Dioxin-8290	3	1	0	1	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45 days	5

Table 12 Upgradient Ground Water Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
EEG-108	Ground Water	VOC-8260	3	1	0	0	3	3-40 ml glass vials w/Teflon septum caps	HCL to pH<2 4°C	14 days	7
		SVOC-8270	3	1	0	0	0	2-1 liter amber glass with Teflon lined screw caps	4°C	7/40 days	4
		Metals-6010	3	1	0	0	0	1- 250 or 500 ml	HNO3 to	180 days	4
		Mercury-7470A	3	1	0	0	0	poly or fluorocarbon	pH<2, 4°C	28 days	4
		Cyanide-9010B	3	1	0	0	0	1-250 or 500 ml poly	NaOH to pH>12, 4°C	14 days	4
		PCB - 680	3	1	0	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	4
		Pesticides-8081A	3	1	0	0	0	4- 1 liter amber glass	4°C	7/40 days	4
		Herbicides-8151A	3	1	0	0	0	w/Teflon lined screw caps			4
		Dioxin-8290	3	1	0	0	0	2- 1 liter amber glass w/Teflon lined screw caps	4°C	30/45 days	4
Total Samples			81	27	9	9	9				135

Table 13 Undeveloped Area Surface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
1	Soil	VOC-5035/8260B	7	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	11
		SVOC-8270C	7	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	9
		Metals-6010B	7	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	9
		Mercury-7471A	7	1	1	0	0	poly or fluorocarbon		28 days	9
		Cyanide-9010B	7	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	9
		PCB - 680	7	1	1	0	0	1-500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	9
		Pesticides-8081A	7	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	9
		Herbicides-8151A	7	1	1	0	0	glass w/Teflon lined lid			9
		Dioxin-8280	2	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	3
2	Soil	VOC-5035/8260B	6	1	0	1	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	10
		SVOC-8270C	6	1	0	1	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	8
		Metals-6010B	6	1	0	1	0	1 - 4 oz widemouth	4°C	180 days	8
		Mercury-7471A	6	1	0	1	0	poly or fluorocarbon		28 days	8
		Cyanide-9010B	6	1	0	1	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	8
		PCB - 680	6	1	0	1	0	1-500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	8
		Pesticides-8081A	6	1	0	1	0	1 - 250 ml widemouth	4°C	14/40 days	8
		Herbicides-8151A	6	1	0	1	0	glass w/Teflon lined lid			8
		Dioxin-8280	1	1	0	1	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	3

Table 13 Undeveloped Area Surface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
3	Soil	VOC-5035/8260B	7	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	11
		SVOC-8270C	7	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	9
		Metals-6010B	7	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	9
		Mercury-7471A	7	1	1	0	0	poly or fluorocarbon		28 days	9
		Cyanide-9010B	7	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	9
		PCB - 680	7	1	1	0	0	1-500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	9
		Pesticides-8081A	7	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	9
		Herbicides-8151A	7	1	1	0	0	glass w/Teflon lined lid			9
		Dioxin-8280	2	1	1	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	4
4	Soil	VOC-5035/8260B	7	1	0	1	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	11
		SVOC-8270C	7	1	0	1	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	9
		Metals-6010B	7	1	0	1	0	1 - 4 oz widemouth	4oC	180 days	9
		Mercury-7471A	7	1	0	1	0	poly or fluorocarbon		28 days	9
		Cyanide-9010B	7	1	0	1	0	1 - 4 oz widemouth glass w/Teflon lined lid	4oC	14 days	9
		PCB - 680	7	1	0	1	0	1-500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	9
		Pesticides-8081A	7	1	0	1	0	1 - 250 ml widemouth	4°C	14/40 days	9
		Herbicides-8151A	7	1	0	1	0	glass w/Teflon lined lid			9
		Dioxin-8280	1	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2

Table 13 Undeveloped Area Surface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
5	Soil	VOC-5035/8260B	6	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	10
		SVOC-8270C	6	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	8
		Metals-6010B	6	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	8
		Mercury-7471A	6	1	1	0	0	poly or fluorocarbon		28 days	8
		Cyanide-9010B	6	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	8
		PCB - 680	6	1	1	0	0	1-500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	8
		Pesticides-8081A	6	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	8
		Herbicides-8151A	6	1	1	0	0	glass w/Teflon lined lid			8
		Dioxin-8280	1	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2
6	Soil	VOC-5035/8260B	5	1	1	1	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	10
		SVOC-8270C	5	1	1	1	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	8
		Metals-6010B	5	1	1	1	0	1 - 4 oz widemouth	4°C	180 days	8
		Mercury-7471A	5	1	1	1	0	poly or fluorocarbon		28 days	8
		Cyanide-9010B	5	1	1	1	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	8
		PCB - 680	5	1	1	1	0	1-500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	8
		Pesticides-8081A	5	1	1	1	0	1 - 250 ml widemouth	4°C	14/40 days	8
		Herbicides-8151A	5	1	1	1	0	glass w/Teflon lined lid			8
		Dioxin-8280	1	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2

Table 13 Undeveloped Area Surface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
7	Soil	VOC-5035/8260B	7	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	11
		SVOC-8270C	7	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	9
		Metals-6010B	7	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	9
		Mercury-7471A	7	1	1	0	0	poly or fluorocarbon		28 days	9
		Cyanide-9010B	7	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	9
		PCB - 680	7	1	1	0	0	1-500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	9
		Pesticides-8081A	7	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	9
		Herbicides-8151A	7	1	1	0	0	glass w/Teflon lined lid			9
		Dioxin-8280	1	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2
Total Samples			369	63	41	25	14				512

[1] or sample will be preserved in accordance with USEPA Method 5035

Table 14 Undeveloped Areas Subsurface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blank Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
1	Soil	VOC-5035/8260B	7	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	11
		SVOC-8270C	7	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	9
		Metals-6010B	7	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	9
		Mercury-7471A	7	1	1	0	0	poly or fluorocarbon		28 days	9
		Cyanide-9010B	7	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	9
		PCB-680	7	1	1	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	9
		Pesticides-8081A	7	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	9
		Herbicides-8151A	7	1	1	0	0	glass w/Teflon lined lid			9
		Dioxin-8280	2	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	3
2	Soil	VOC-5035/8260B	6	1	0	1	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	10
		SVOC-8270C	6	1	0	1	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	8
		Metals-6010B	6	1	0	1	0	1 - 4 oz widemouth	4°C	180 days	8
		Mercury-7471A	6	1	0	1	0	poly or fluorocarbon		28 days	8
		Cyanide-9010B	6	1	0	1	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	8
		PCB-680	6	1	0	1	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	8
		Pesticides-8081A	6	1	0	1	0	1 - 250 ml widemouth	4°C	14/40 days	8
		Herbicides-8151A	6	1	0	1	0	glass w/Teflon lined lid			8
		Dioxin-8280	1	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2

Table 14 Undeveloped Areas Subsurface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blank Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
3	Soil	VOC-5035/8260B	7	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	11
		SVOC-8270C	7	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	9
		Metals-6010B	7	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	9
		Mercury-7471A	7	1	1	0	0	poly or fluorocarbon		28 days	9
		Cyanide-9010B	7	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	9
		PCB-680	7	1	1	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	9
		Pesticides-8081A	7	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	9
		Herbicides-8151A	7	1	1	0	0	glass w/Teflon lined lid			9
		Dioxin-8280	1	1	1	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	3
4	Soil	VOC-5035/8260B	7	1	0	1	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	11
		SVOC-8270C	7	1	0	1	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	9
		Metals-6010B	7	1	0	1	0	1 - 4 oz widemouth	4°C	180 days	9
		Mercury-7471A	7	1	0	1	0	poly or fluorocarbon		28 days	9
		Cyanide-9010B	7	1	0	1	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	9
		PCB-680	7	1	0	1	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	9
		Pesticides-8081A	7	1	0	1	0	1 - 250 ml widemouth	4°C	14/40 days	9
		Herbicides-8151A	7	1	0	1	0	glass w/Teflon lined lid			9
		Dioxin-8280	1	1	0	1	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	3

Table 14 Undeveloped Areas Subsurface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blank Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
5	Soil	VOC-5035/8260B	6	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	10
		SVOC-8270C	6	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	8
		Metals-6010B	6	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	8
		Mercury-7471A	6	1	1	0	0	poly or fluorocarbon		28 days	8
		Cyanide-9010B	6	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	8
		PCB-680	6	1	1	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	8
		Pesticides-8081A	6	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	8
		Herbicides-8151A	6	1	1	0	0	glass w/Teflon lined lid			8
		Dioxin-8280	2	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	3
6	Soil	VOC-5035/8260B	5	1	1	1	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	10
		SVOC-8270C	5	1	1	1	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	8
		Metals-6010B	5	1	1	1	0	1 - 4 oz widemouth	4°C	180 days	8
		Mercury-7471A	5	1	1	1	0	poly or fluorocarbon		28 days	8
		Cyanide-9010B	5	1	1	1	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	8
		PCB-680	5	1	1	1	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	8
		Pesticides-8081A	5	1	1	1	0	1 - 250 ml widemouth	4°C	14/40 days	8
		Herbicides-8151A	5	1	1	1	0	glass w/Teflon lined lid			8
		Dioxin-8280	1	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2

Table 14 Undeveloped Areas Subsurface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blank Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
7	Soil	VOC-5035/8260B	7	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	11
		SVOC-8270C	7	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	9
		Metals-6010B	7	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	9
		Mercury-7471A	7	1	1	0	0	poly or fluorocarbon		28 days	9
		Cyanide-9010B	7	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	9
		PCB-680	7	1	1	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	9
		Pesticides-8081A	7	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	9
		Herbicides-8151A	7	1	1	0	0	glass w/Teflon lined lid			9
		Dioxin-8280	1	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2
Total Samples			369	63	41	25	14				512

1---or sample will be preserved in accordance with USEPA method 5035

Table 15 Developed Area Surface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
1	Soil	VOC-5035/8260B	3	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	7
		SVOC-8270C	3	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	5
		Metals-6010B	3	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	5
		Mercury-7471A	3	1	1	0	0	poly or fluorocarbon		28 days	5
		Cyanide-9010B	3	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	5
		PCB - 680	3	1	1	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	5
		Pesticides-8081A	3	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	5
		Herbicides-8151A	3	1	1	0	0	glass w/Teflon lined lid			5
		Dioxin-8280	1	1	1	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	3
2	Soil	VOC-5035/8260B	3	0	0	1	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	6
		SVOC-8270C	3	0	0	1	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	4
		Metals-6010B	3	0	0	1	0	1 - 4 oz widemouth	4°C	180 days	4
		Mercury-7471A	3	0	0	1	0	poly or fluorocarbon		28 days	4
		Cyanide-9010B	3	0	0	1	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	4
		PCB - 680	3	0	0	1	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	4
		Pesticides-8081A	3	0	0	1	0	1 - 250 ml widemouth	4°C	14/40 days	4
		Herbicides-8151A	3	0	0	1	0	glass w/Teflon lined lid			4
		Dioxin-8280	0	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	0

Table 15 Developed Area Surface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
3	Soil	VOC-5035/8260B	3	0	0	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	5
		SVOC-8270C	3	0	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	3
		Metals-6010B	3	0	0	0	0	1 - 4 oz widemouth	4°C	180 days	3
		Mercury-7471A	3	0	0	0	0	poly or fluorocarbon		28 days	3
		Cyanide-9010B	3	0	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	3
		PCB - 680	3	0	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	3
		Pesticides-8081A	3	0	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	3
		Herbicides-8151A	3	0	0	0	0	glass w/Teflon lined lid			3
		Dioxin-8280	1	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	1
4	Soil	VOC-5035/8260B	3	0	0	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	5
		SVOC-8270C	3	0	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	3
		Metals-6010B	3	0	0	0	0	1 - 4 oz widemouth	4°C	180 days	3
		Mercury-7471A	3	0	0	0	0	poly or fluorocarbon		28 days	3
		Cyanide-9010B	3	0	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	3
		PCB - 680	3	0	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	3
		Pesticides-8081A	3	0	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	3
		Herbicides-8151A	3	0	0	0	0	glass w/Teflon lined lid			3
		Dioxin-8280	0	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	0

Table 15 Developed Area Surface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
5	Soil	VOC-5035/8260B	3	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	7
		SVOC-8270C	3	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	5
		Metals-6010B	3	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	5
		Mercury-7471A	3	1	1	0	0	poly or fluorocarbon		28 days	5
		Cyanide-9010B	3	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	5
		PCB - 680	3	1	1	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	5
		Pesticides-8081A	3	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	5
		Herbicides-8151A	3	1	1	0	0	glass w/Teflon lined lid			5
		Dioxin-8280	1	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2
6	Soil	VOC-5035/8260B	3	0	0	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	5
		SVOC-8270C	3	0	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	3
		Metals-6010B	3	0	0	0	0	1 - 4 oz widemouth	4°C	180 days	3
		Mercury-7471A	3	0	0	0	0	poly or fluorocarbon		28 days	3
		Cyanide-9010B	3	0	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	3
		PCB - 680	3	0	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	3
		Pesticides-8081A	3	0	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	3
		Herbicides-8151A	3	0	0	0	0	glass w/Teflon lined lid			3
		Dioxin-8280	0	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	0

Table 15 Developed Area Surface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
7	Soil	VOC-5035/8260B	2	0	0	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	4
		SVOC-8270C	2	0	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	2
		Metals-6010B	2	0	0	0	0	1 - 4 oz widemouth	4°C	180 days	2
		Mercury-7471A	2	0	0	0	0	poly or fluorocarbon		28 days	2
		Cyanide-9010B	2	0	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	2
		PCB - 680	2	0	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	2
		Pesticides-8081A	2	0	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	2
		Herbicides-8151A	2	0	0	0	0	glass w/Teflon lined lid			2
		Dioxin-8280	1	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	1
Total Samples			164	18	17	8	14				221

[1] or sample will be preserved in accordance with USEPA Method 5035

Table 16 Developed Area Subsurface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
1	Soil	VOC-5035/8260B	3	0	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	6
		SVOC-8270C	3	0	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	4
		Metals-6010B	3	0	1	0	0	1 - 4 oz widemouth	4°C	180 days	4
		Mercury-7471A	3	0	1	0	0	poly or fluorocarbon		28 days	4
		Cyanide-9010B	3	0	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	4
		PCB-680	3	0	1	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	4
		Pesticides-8081A	3	0	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	4
		Herbicides-8151A	3	0	1	0	0	glass w/Teflon lined lid			4
		Dioxin-8280	0	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	0
2	Soil	VOC-5035/8260B	3	1	0	1	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	7
		SVOC-8270C	3	1	0	1	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	5
		Metals-6010B	3	1	0	1	0	1 - 4 oz widemouth	4°C	180 days	5
		Mercury-7471A	3	1	0	1	0	poly or fluorocarbon		28 days	5
		Cyanide-9010B	3	1	0	1	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	5
		PCB-680	3	1	0	1	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	5
		Pesticides-8081A	3	1	0	1	0	1 - 250 ml widemouth	4°C	14/40 days	5
		Herbicides-8151A	3	1	0	1	0	glass w/Teflon lined lid			5
		Dioxin-8280	1	1	0	1	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	3

Table 16 Developed Area Subsurface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
3	Soil	VOC-5035/8260B	3	0	0	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	5
		SVOC-8270C	3	0	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	3
		Metals-6010B	3	0	0	0	0	1 - 4 oz widemouth	4°C	180 days	3
		Mercury-7471A	3	0	0	0	0	poly or fluorocarbon		28 days	3
		Cyanide-9010B	3	0	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	3
		PCB-680	3	0	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	3
		Pesticides-8081A	3	0	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	3
		Herbicides-8151A	3	0	0	0	0	glass w/Teflon lined lid			3
		Dioxin-8280	0	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	0
4	Soil	VOC-5035/8260B	3	0	0	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	5
		SVOC-8270C	3	0	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	3
		Metals-6010B	3	0	0	0	0	1 - 4 oz widemouth	4°C	180 days	3
		Mercury-7471A	3	0	0	0	0	poly or fluorocarbon		28 days	3
		Cyanide-9010B	3	0	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	3
		PCB-680	3	0	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	3
		Pesticides-8081A	3	0	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	3
		Herbicides-8151A	3	0	0	0	0	glass w/Teflon lined lid			3
		Dioxin-8280	1	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	1

Table 16 Developed Area Subsurface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
5	Soil	VOC-5035/8260B	3	1	1	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	7
		SVOC-8270C	3	1	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	5
		Metals-6010B	3	1	1	0	0	1 - 4 oz widemouth	4°C	180 days	5
		Mercury-7471A	3	1	1	0	0	poly or fluorocarbon		28 days	5
		Cyanide-9010B	3	1	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	5
		PCB-680	3	1	1	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	5
		Pesticides-8081A	3	1	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	5
		Herbicides-8151A	3	1	1	0	0	glass w/Teflon lined lid			5
		Dioxin-8280	0	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	0
6	Soil	VOC-5035/8260B	3	0	0	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	5
		SVOC-8270C	3	0	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	3
		Metals-6010B	3	0	0	0	0	1 - 4 oz widemouth	4°C	180 days	3
		Mercury-7471A	3	0	0	0	0	poly or fluorocarbon		28 days	3
		Cyanide-9010B	3	0	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	3
		PCB-680	3	0	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	3
		Pesticides-8081A	3	0	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	3
		Herbicides-8151A	3	0	0	0	0	glass w/Teflon lined lid			3
		Dioxin-8280	1	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	1

Table 16 Developed Area Subsurface Soil Sampling - Sample and Analysis Summary

Transect	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
7	Soil	VOC-5035/8260B	2	0	0	0	2	3- 5 gm Encore[1]	4°C	48 hours/14 days	4
		SVOC-8270C	2	0	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	2
		Metals-6010B	2	0	0	0	0	1 - 4 oz widemouth	4°C	180 days	2
		Mercury-7471A	2	0	0	0	0	poly or fluorocarbon		28 days	2
		Cyanide-9010B	2	0	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	2
		PCB-680	2	0	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	2
		Pesticides-8081A	2	0	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	2
		Herbicides-8151A	2	0	0	0	0	glass w/Teflon lined lid			2
		Dioxin-8280	1	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	1
Total Samples			164	17	16	9	14				220

[1] or sample will be preserved in accordance with USEPA Method 5035

Table 17 Background Soil Samples - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
EE-04	Soil	VOC-5035/8260B	2	0	1	0	1	3- 5 gm Encore[1]	4°C	48 hours/14 days	4
		SVOC-8270C	2	0	1	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	3
		Metals-6010B	2	0	1	0	0	1 - 4 oz widemouth	4°C	180 days	3
		Mercury-7471A	2	0	1	0	0	poly or fluorocarbon		28 days	3
		Cyanide-9010B	2	0	1	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	3
		PCB-680	2	0	1	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	3
		Pesticides-8081A	2	0	1	0	0	1 - 250 ml widemouth	4°C	14/40 days	3
		Herbicides-8151A	2	0	1	0	0	glass w/Teflon lined lid			3
		Dioxin-8280	2	0	1	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	3
EE-20	Soil	VOC-5035/8260B	2	1	0	1	0	3- 5 gm Encore[1]	4°C	48 hours/14 days	4
		SVOC-8270C	2	1	0	1	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	4
		Metals-6010B	2	1	0	1	0	1 - 4 oz widemouth	4°C	180 days	4
		Mercury-7471A	2	1	0	1	0	poly or fluorocarbon		28 days	4
		Cyanide-9010B	2	1	0	1	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	4
		PCB-680	2	1	0	1	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	4
		Pesticides-8081A	2	1	0	1	0	1 - 250 ml widemouth	4°C	14/40 days	4
		Herbicides-8151A	2	1	0	1	0	glass w/Teflon lined lid			4
		Dioxin-8280	2	1	0	1	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	4

Table 17 Background Soil Samples - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
EE-108	Soil	VOC-5035/8260B	2	0	0	0	1	3- 5 gm Encore[1]	4°C	48 hours/14 days	3
		SVOC-8270C	2	0	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	2
		Metals-6010B	2	0	0	0	0	1 - 4 oz widemouth	4°C	180 days	2
		Mercury-7471A	2	0	0	0	0	poly or fluorocarbon		28 days	2
		Cyanide-9010B	2	0	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	2
		PCB-680	2	0	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	2
		Pesticides-8081A	2	0	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	2
		Herbicides-8151A	2	0	0	0	0	glass w/Teflon lined lid			2
		Dioxin-8280	2	0	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2
Total Samples			54	9	9	9	2				83

[1] ---or sample will be preserved in accordance with USEPA method 5035

Table 18 Undeveloped Area Sediment Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Dead Creek Segment B & F	Sediment	PCB-680	50	10	5	3	0	1 - 500 ml wide mouth glass w/Teflon lined lid	4°C	14/40 days	68
		TPH-8015B	50	10	5	3	0	2 - 4 oz widemouth glass w/Teflon lined lid	4°C	14/40 days	68
		Copper-7211	50	10	5	3	0	1 - 4oz wide mouth	4°C	180 days	68
		Zinc-7951	50	10	5	3	0	poly or fluorocarbon			68
		TOC-9060	50	10	5	3	0	1 - 4oz wide mouth glass w/Teflon lined lid	4°C	28 days	68
		Grain Size	50	10	0	0	0				60
		Solids Content-SM-2540G	50	10	5	3	0				68
Total Samples			350	70	30	18	0				468

Table 19 Developed Area Sediment Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Dead Creek Segments C,D, & E	Sediment	PCB-680	47	10	5	3	0	1 - 500 ml wide mouth glass w/Teflon lined lid	4°C	14/40 days	65
		TPH-8015B	47	10	5	3	0	2 - 4 oz widemouth glass w/Teflon lined lid	4°C	14/40 days	65
		Copper-7211	47	10	5	3	0	1 - 4oz wide mouth	4°C	180 days	65
		Zinc-7951	47	10	5	3	0	poly or fluorocarbon			65
		TOC-9060	47	10	5	3	0	1 - 4oz wide mouth glass w/Teflon lined lid	4°C	28 days	65
		Grain Size	47	10	0	0	0				57
		Solids Content-SM-2540G	47	10	5	3	0				65
Total Samples			329	70	30	18	10				447

Table 20 Borrow Pit Lake Sediment Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Borrow Pit Lake	Sediment	PCB-680	8	2	1	1	0	1 - 500 ml wide mouth glass w/Teflon lined lid	4°C	14/40 days	12
		TPH-8015B	8	2	1	1	0	2 - 4 oz widemouth glass w/Teflon lined lid	4°C	14/40 days	12
		Copper-7211	8	2	1	1	0	1 - 4oz wide mouth poly or fluorocarbon	4°C	180 days	12
		Zinc-7951	8	2	1	1	0				12
		TOC-9060	8	2	1	1	0	1 - 4oz wide mouth glass w/Teflon lined lid	4°C	28 days	12
		Grain Size	8	2	0	0	0				10
		Solids Content-SM-2540G	8	2	1	1	0				12
Total Samples			56	14	6	6	0				82

Table 21 Dead Creek Sediment Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Dead Creek Segments B through F	Sediment	VOC-5035/8260B	18	3	1	1	5	3- 5 gm Encore[1]	4°C	48 hours/14 days	28
		SVOC-8270C	18	3	1	1		1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	23
		Metals-6010B	18	3	1	1		1 - 4 oz widemouth poly or fluorocarbon	4°C	180 days	23
		Mercury-7471A	18	3	1	1				28 days	23
		Cyanide-9010B	18	3	1	1		1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	23
		PCB-680	18	3	1	1		1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	23
		Pesticides-8081A	18	3	1	1		1 - 250 ml widemouth glass w/Teflon lined lid	4°C		23
		Herbicides-8151A	18	3	1	1					23
		Dioxin-8290	18	3	1	1		100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	23
		TOC-9060	18	3	1	0	0	1 - 4oz wide mouth glass w/Teflon lined lid	4°C	28 days	23
		Grain Size	18	0	0	0	0				18
		Solids Content-SM-2540G	18	0	1	0	0				18

Table 21 Dead Creek Sediment Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Borrow Pit Lake	Sediment	VOC-5035/8260B	2	1	1	0	1	3- 5 gm Encore[1].	4°C	48 hours/14 days	5
		SVOC-8270C	2	1	1	0		1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	4
		Metals-6010B	2	1	1	0		1 - 4 oz widemouth poly or fluorocarbon	4°C	180 days	4
		Mercury-7471A	2	1	1	0				28 days	4
		Cyanide-9010B	2	1	1	0		1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	4
		PCB-680	2	1	1	0		1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	4
		Pesticides-8081A	2	1	1	0		1 - 250 ml widemouth glass w/Teflon lined lid	4°C		4
		Herbicides-8151A	2	1	1	0					4
		Dioxin-8290	2	1	1	0		100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	4
		TOC-9060	2	1	1	0	0	1 - 4oz wide mouth glass w/Teflon lined lid	4°C	28 days	4
		Grain Size	2	0	0	0	0				2
		Solids Content-SM-2540G	2	0	1	0	0				3
Total Samples			240	40	22	12	6				320

[1] or sample will be preserved in accordance with USEPA Method 5035

Table 22 Dead Creek Ecological Sediment Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Site M	Sediment	VOC-5035/8260B	1	1	0	0	0	3- 5 gm Encore[1]	4°C	48 hours	2
		SVOC-8270C	1	1	0	0	0	1-250 ml widemouth glass with Teflon lined lid	4°C	14/40 days	2
		Metals-6010B	1	1	0	0	0	1 - 4 oz widemouth	4°C	180 days	2
		Mercury-7471A	1	1	0	0	0	poly or fluorocarbon		28 days	2
		Cyanide-9010B	1	1	0	0	0	1 - 4 oz widemouth glass w/Teflon lined lid	4°C	14 days	2
		PCB-680	1	1	0	0	0	1 - 500 ml widemouth glass w/Teflon lined lid	4°C	14/40 days	2
		Pesticides-8081A	1	1	0	0	0	1 - 250 ml widemouth	4°C	14/40 days	2
		Herbicides-8151A	1	1	0	0	0	glass w/Teflon lined lid			2
		Dioxin-8290	1	1	0	0	0	100 gm in 1-4 oz amber glass jar w/Teflon lined lid	4°C	30/45 days	2
Total Samples			207	63	27	18	8				323

1 or sample will be preserved in accordance with USEPA Method5035

Table 23 Surface Water Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmenta Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Dead Creek Segment B through Segment F	Water	VOC-8260B	18	4	1	1	10	3-40 ml glass vials w/Teflon lined septum caps	HCL to pH<2 4°C	14 days	34
		SVOC-8270C	18	4	1	1	0	2-1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	24
		Metals-6010A	18	4	1	1		1-250 or 500 ml poly or fluorocarbon	HNO_3 to pH<2	180 days	24
		Mercury-7470A	18	4	1	1			4°C	28 days	24
		Cyanide-9010B	18	4	1	1	0	1-250 or 500 ml poly	NaOH to pH >12, 4°C	14 days	24
		PCB--680	18	4	1	1	0	4 - 1 liter amber glass w/Teflon lined screw cap	4°C	7/40 days	24
		Pesticides-8081A	18	4	1	1	0	4 - 1 liter amber glass w/Teflon lined screw cap	4°C	7/40 days	24
		Herbicides-8151A	18	4	1	1	0				24
		Dioxin-8290	18	4	1	1	0	2-1 liter amber glass w/Teflon lined screw caps	4°C	30/45	24
		TSS-160.2	18	4	1	1	0	1 - 250 or 500 ml poly	4°C	7 days	24
		TDS-160.1	18	4	1	1	0	1-250 or 500 ml poly	4°C	7 days	24
		Hardness-130.1/130.2	18	4	1	1	0	1-250 ml poly or fluorocarbon	4°C $HNO_3$to pH<2	6 months	24
		pH-150.1/150.2	18	4	1	1	0	1 - 100ml poly	4°C	As soon as possible	24
		Fluoride-300.0	18	4	1	1	0	1-250 or 500 ml plastic bottle	4°C	28 days	24
		Total Phosphorus -365.4	18	4	1	1	0	1- 1 liter plastic bottle	2 ml H_2SO_4 4°C	28 days	24
		Orthophosphate -300.0	18	4	1	1	0	1- 1 liter plastic bottle	2 ml H_2SO_4 4°C	48 hours	24

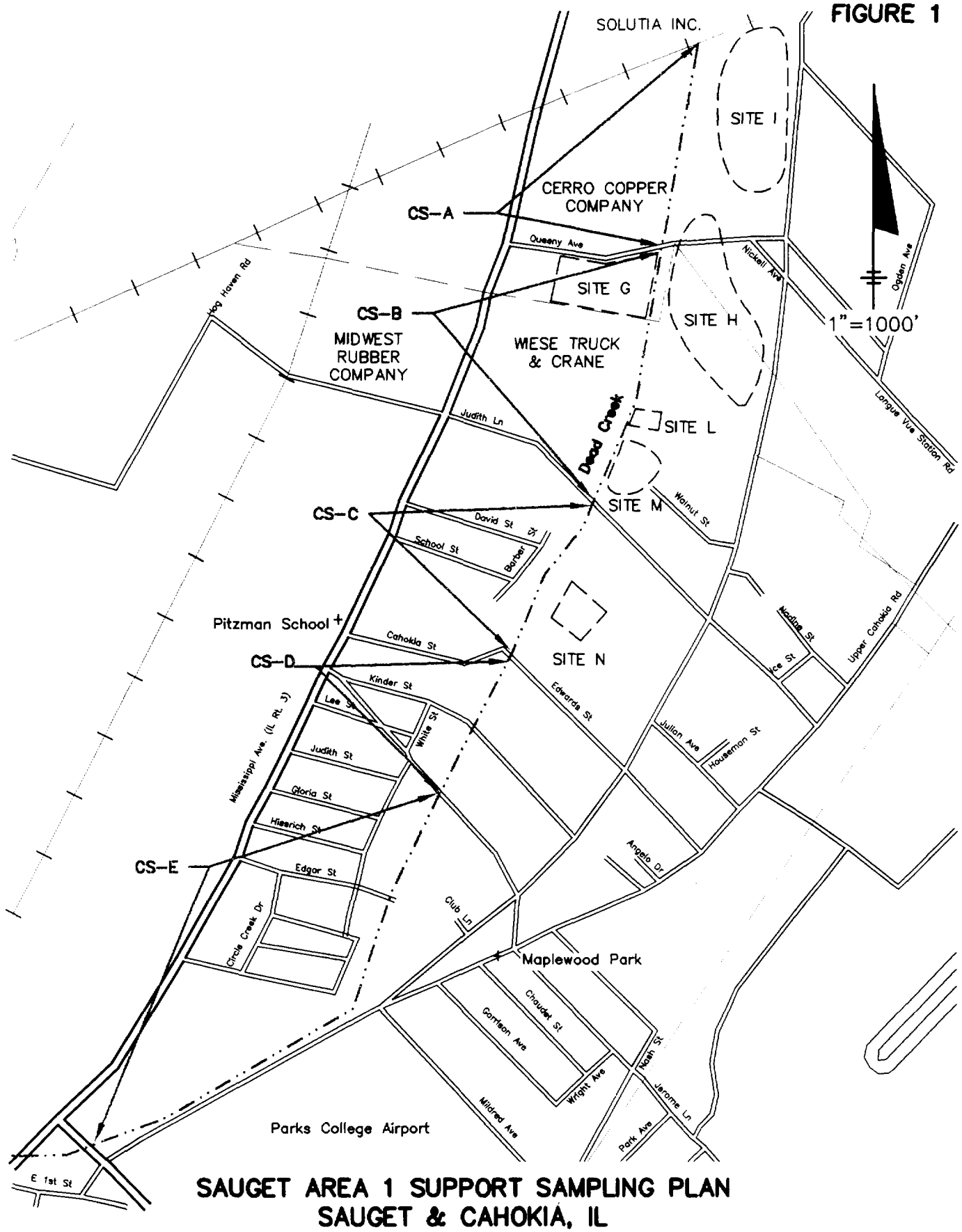
Table 23 Surface Water Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmenta Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
Borrow Pit Lake	Water	VOC-8260B	2	0	1	0	0	3-40 ml glass vials w/Teflon lined septum caps	HCL to pH<2 4°C	14 days	3
		SVOC-8270C	2	0	1	0	0	2-1 liter amber glass w/Teflon lined screw caps	4°C	7/40 days	3
		Metals-6010A	2	0	1	0		1-250 or 500 ml poly or fluorocarbon	HNO_3 to pH<2 4°C	180 days	3
		Mercury-7470A	2	0	1	0				28 days	3
		Cyanide-9010B	2	0	1	0	0	1-250 or 500 ml poly	NaOH to pH >12, 4°C	14 days	3
		PCB--680	2	0	1	0	0	4 - 1 liter amber glass w/Teflon lined screw cap	4°C	7/40 days	3
		Pesticides-8081A	2	0	1	0	0	4 - 1 liter amber glass w/Teflon lined screw cap	4°C	7/40 days	3
		Herbicides-8151A	2	0	1	0	0				3
		Dioxin-8290	2	0	1	0	0	2-1 liter amber glass w/Teflon lined screw caps	4°C	30/45	3
		TSS-160.2	2	0	1	0	0	1 - 250 or 500 ml poly	4°C	7 days	3
		TDS-160.1	2	0	1	0	0	1-250 or 500 ml poly	4°C	7 days	3
		Hardness-130.1/130.2	2	0	1	0	0	1-250 ml poly or fluorocarbon	4°C $HNO_3$to pH<2	6 months	3
		pH-150.1/150.2	2	0	1	0	0	1 - 100ml poly	4°C	As soon as possible	3
		Fluoride-300.0	2	0	1	0	0	1-250 or 500 ml plastic bottle	4°C	28 days	3
		Total Phosphorus -365.4	2	0	1	0	0	1- 1 liter plastic bottle	2 ml H_2SO_4 4°C	28 days	3
		Orthophosphate -300.0	2	0	1	0	0	1- 1 liter plastic bottle	2 ml H_2SO_4 4°C	48 hours	3
Total Samples			320	64	32	16	10				442

Table 24 Air Sampling - Sample and Analysis Summary

Station	Matrix	Parameters	Number of Environmental Samples	Number of Field Blanks/ Equipment Blanks	Number of Field Duplicates	Number of Matrix Spike/Matrix Spike Duplicates or Spike Duplicates	Number of Trip Blanks	Sample Containers (number,size, type)	Preservation	Holding Time extraction/analysis	Total Analyses
G	Air	VOC - TO-1	4	1	0	0	1	1- Sorbent Tube	4°C	7 days	6
		SVOC-TO13	4	1	0	0	0	PUF	4°C	7 days	5
		PCB-TO-4	4	1	0	0	0	PUF	4°C	7 days	5
		Dioxins-TO-9	4	1	0	0	0	PUF	4°C	7 days	5
		Metals-6010B	4	1	0	0	0	PM 2.5	4°C	7 days	5
H,I,L	Air	VOC - TO-1	9	0	0	0	2	1- Sorbent Tube	4°C	7 days	11
		SVOC-TO13	9	0	0	0	0	PUF	0°C	7 days	9
		PCB-TO-4	9	0	0	0	0	PUF	4°C	7 days	9
		Dioxins-TO-9	9	0	0	0	0	PUF	4°C	7 days	9
		Metals-6010B	9	0	0	0	0	PM 2.5	4°C	7 days	9
Total Samples			65	5	0	0	3				73

FIGURE 1



SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET & CAHOKIA, IL

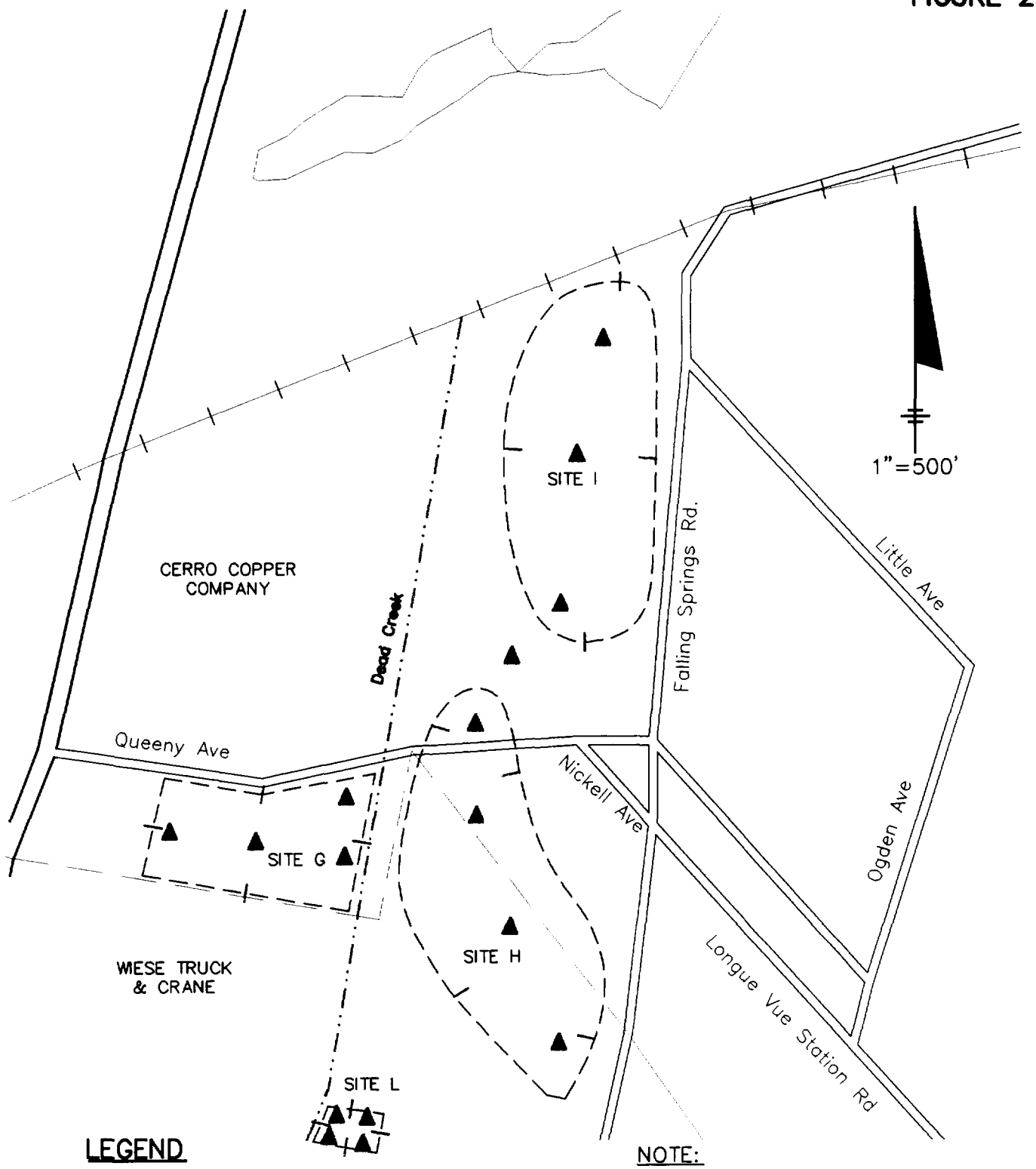
FILL AREA & CREEK SECTOR LOCATION MAP

23548.010.05
3/29/99

O'BRIEN & GERE ENGINEERS INC.

PLOT DATE: 4/1/99

FIGURE 2



LEGEND

— BOUNDARY CONFIRMATION TRENCH

▲ WASTE CHARACTERIZATION BORING

NOTE:

1. TRENCH AND BORING LOCATIONS WILL BE FINALIZED AFTER COMPLETING AIR PHOTO ANALYSIS OF THE FILL AREAS.

SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET & CAHOKIA, IL

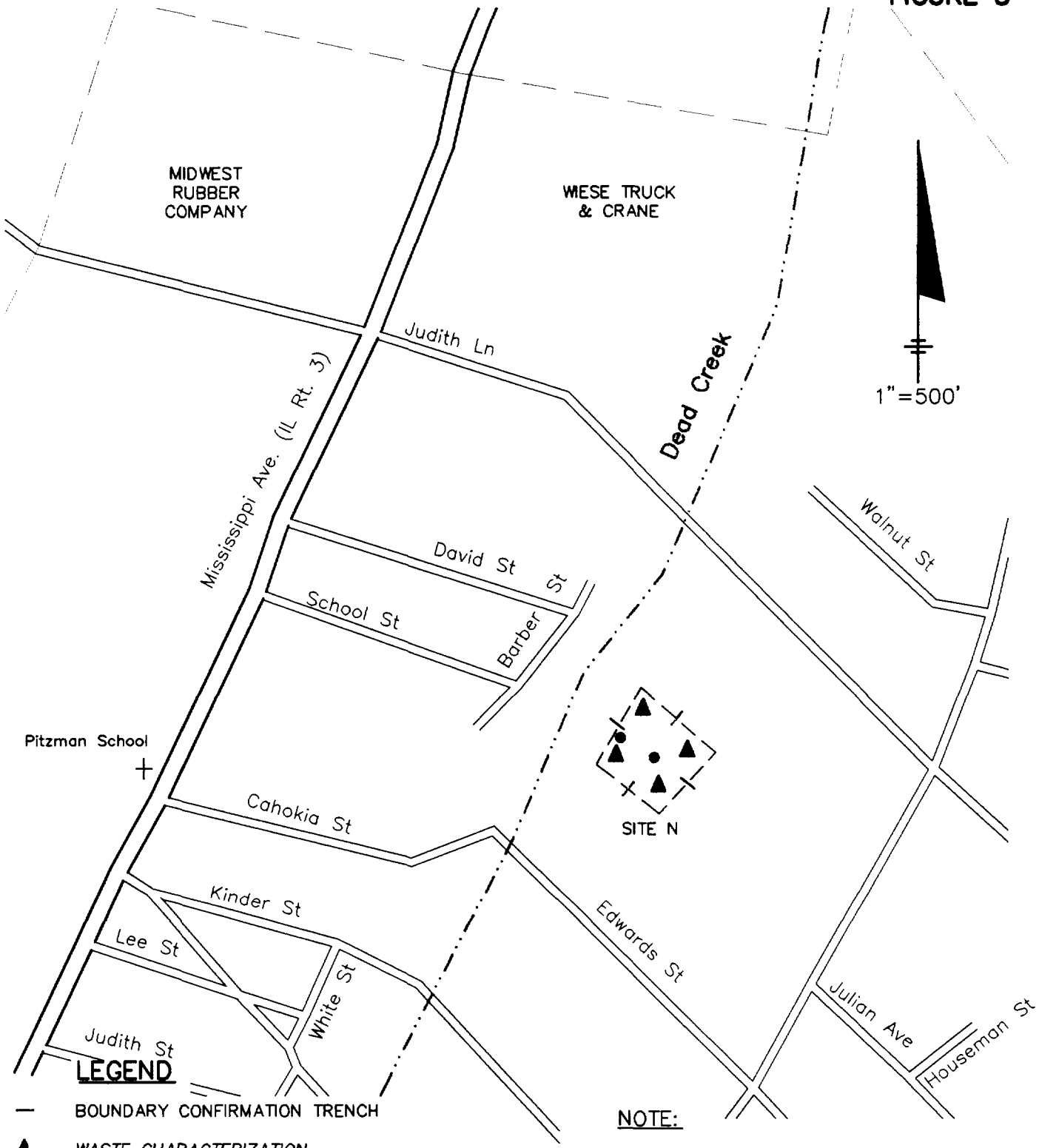
PRELIMINARY BOUNDARY CONFIRMATION TRENCH & WASTE CHARACTERIZATION BORING LOCATIONS AT SITES G, H, I & L

23548.010.06
3/29/99

CRAIG & GERE ENGINEERS INC.

PLOT DATE: 4/1/99

FIGURE 3



SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET AND CAHOKIA, IL

PRELIMINARY BOUNDARY CONFIRMATION TRENCH & WASTE CHARACTERIZATION BORING LOCATIONS AT SITE N

23548.010.07
3/30/99

O'BRIEN & GERE ENGINEERS INC.

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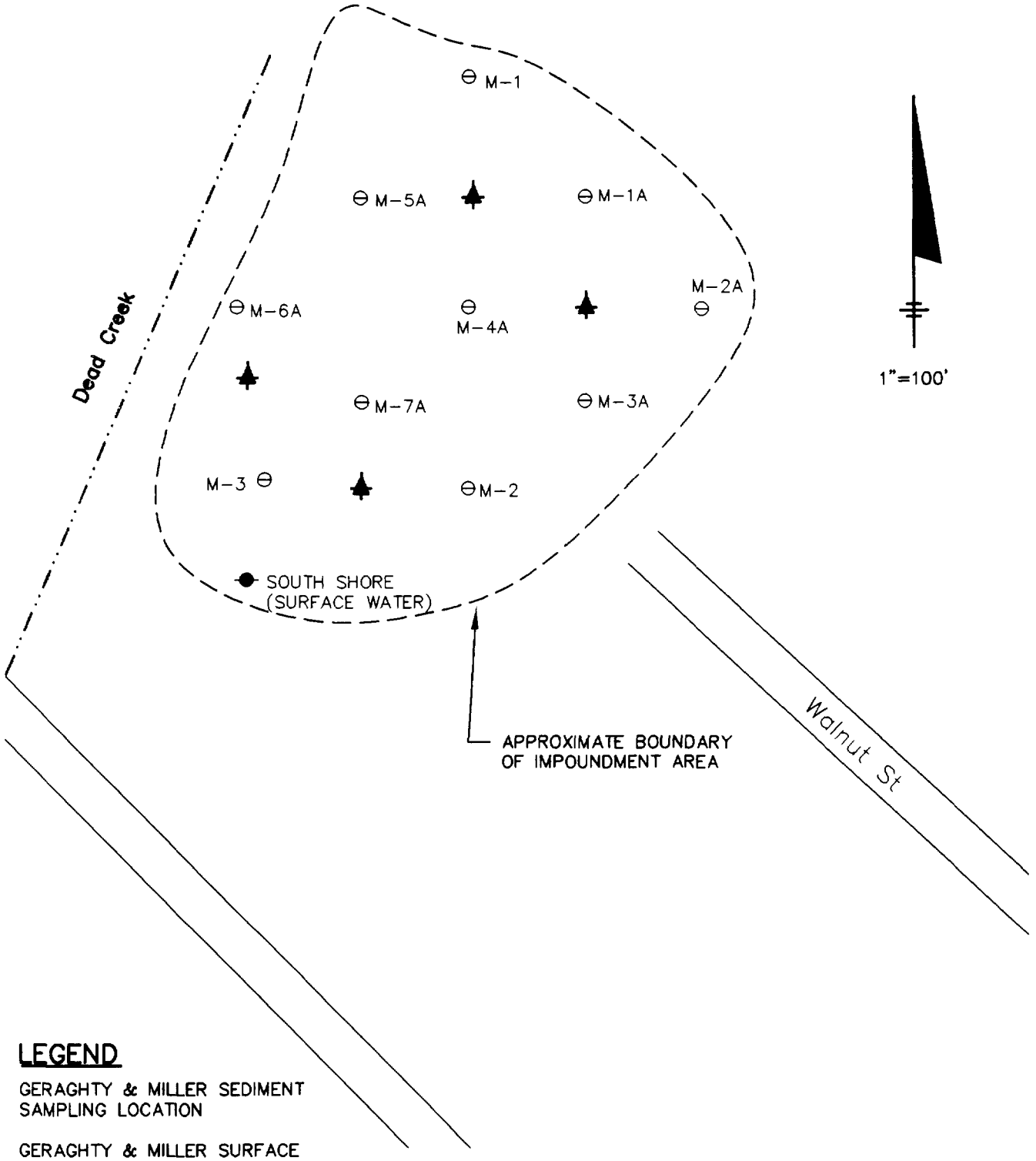
PLOT DATE: 4/1/99

FIGURE 4



LEGEND

- GERAGHTY & MILLER SEDIMENT SAMPLING LOCATION
- GERAGHTY & MILLER SURFACE WATER SAMPLING LOCATION
- SSP WASTE CHARACTERIZATION SAMPLING LOCATION

SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET AND CAHOKIA, IL

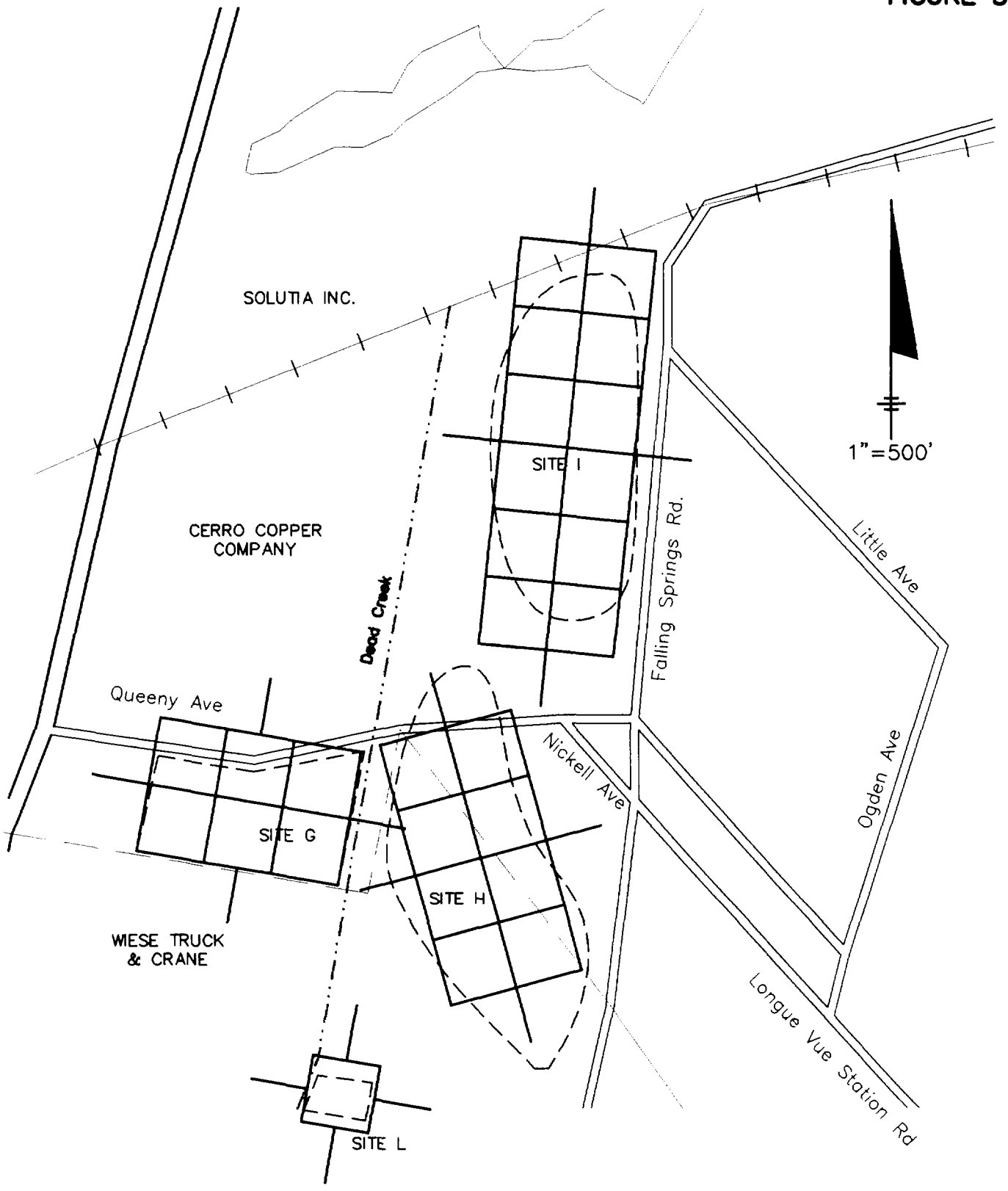
PRELIMINARY WASTE CHARACTERIZATION SAMPLING LOCATIONS AT SITE M

23548.010.08
3/30/99

O'BRIEN & GERE ENGINEERS INC.

DWG PATH: I:\PROJECTS\10040\23548\L 8.DWG 1=200
PLOT DATE: 4/1,

FIGURE 5



SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET & CAHOKIA, IL

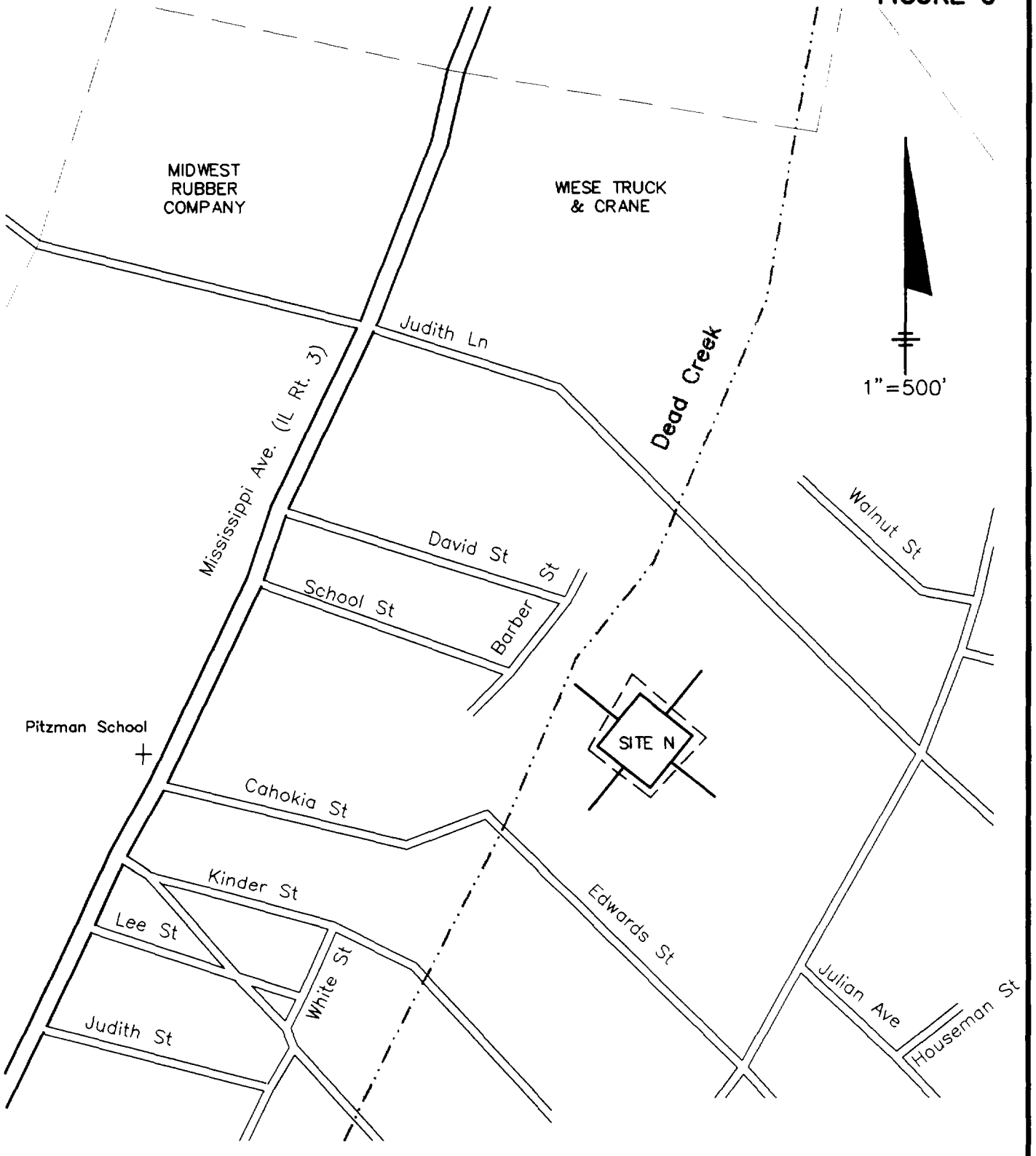
SOIL GAS SURVEY SAMPLING GRID AT SITES G, H, I & L

23548.010.09
3/30/99

O'BRIEN & GERE ENGINEERS INC.

PLOT DATE: 3/30/99

FIGURE 6



SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET AND CAHOKIA, IL

SOIL GAS SURVEY SAMPLING GRID AT SITE N

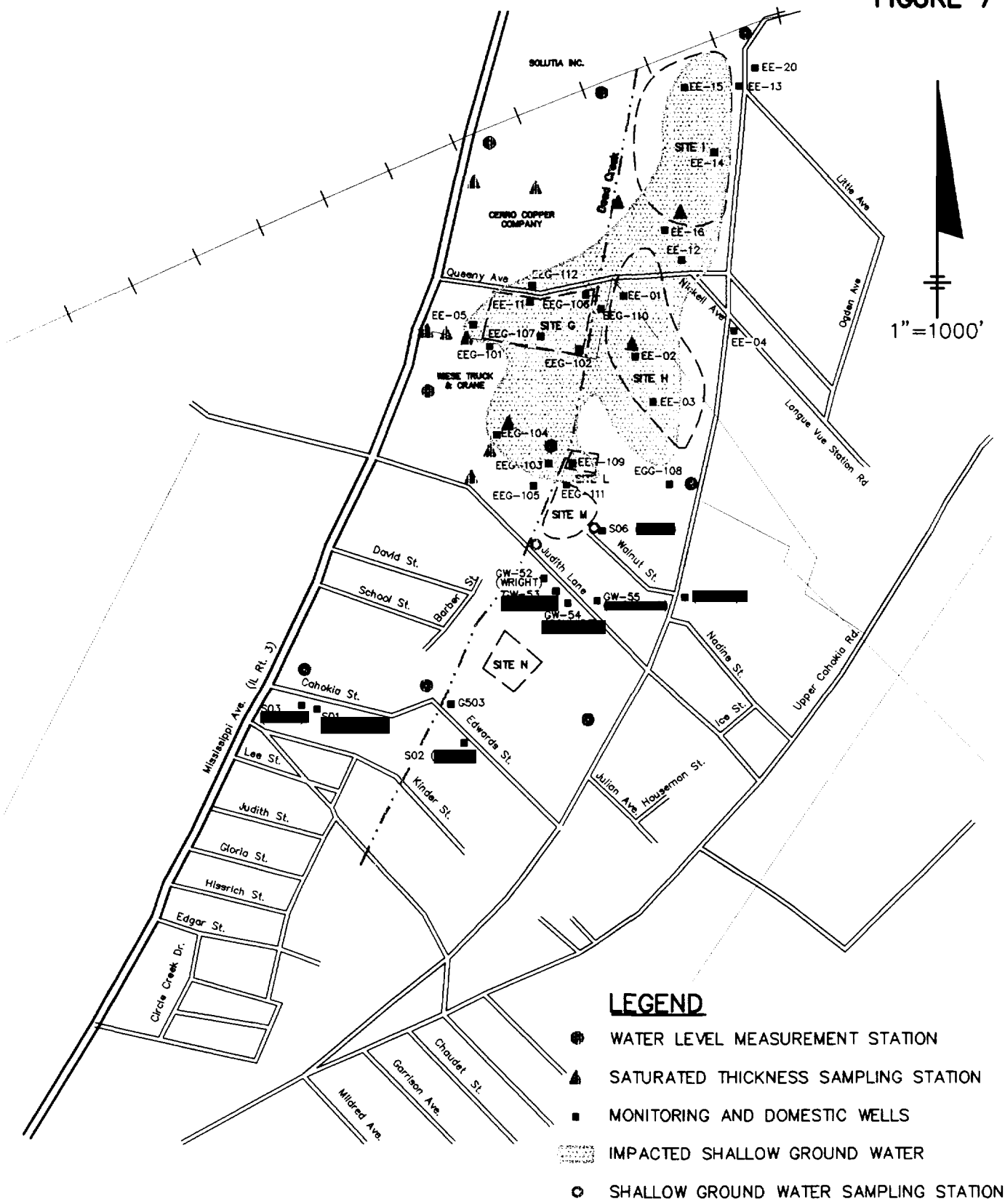
23548.010.10
3/30/99

O'BRIEN & GERE ENGINEERS INC.

DWG PATH: I:\PROJECTS\10040\23548\DWG\10.DWG 1=500

PLOT DATE: 3/30/99

FIGURE 7



LEGEND

- WATER LEVEL MEASUREMENT STATION
- SATURATED THICKNESS SAMPLING STATION
- MONITORING AND DOMESTIC WELLS
- IMPACTED SHALLOW GROUND WATER
- SHALLOW GROUND WATER SAMPLING STATION

SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET & CAHOKIA, IL

GROUND WATER SAMPLING LOCATIONS

23548.010.11
3/30/99

O'BRIEN & GERE ENGINEERS INC.

PLOT DATE: 3/30/99

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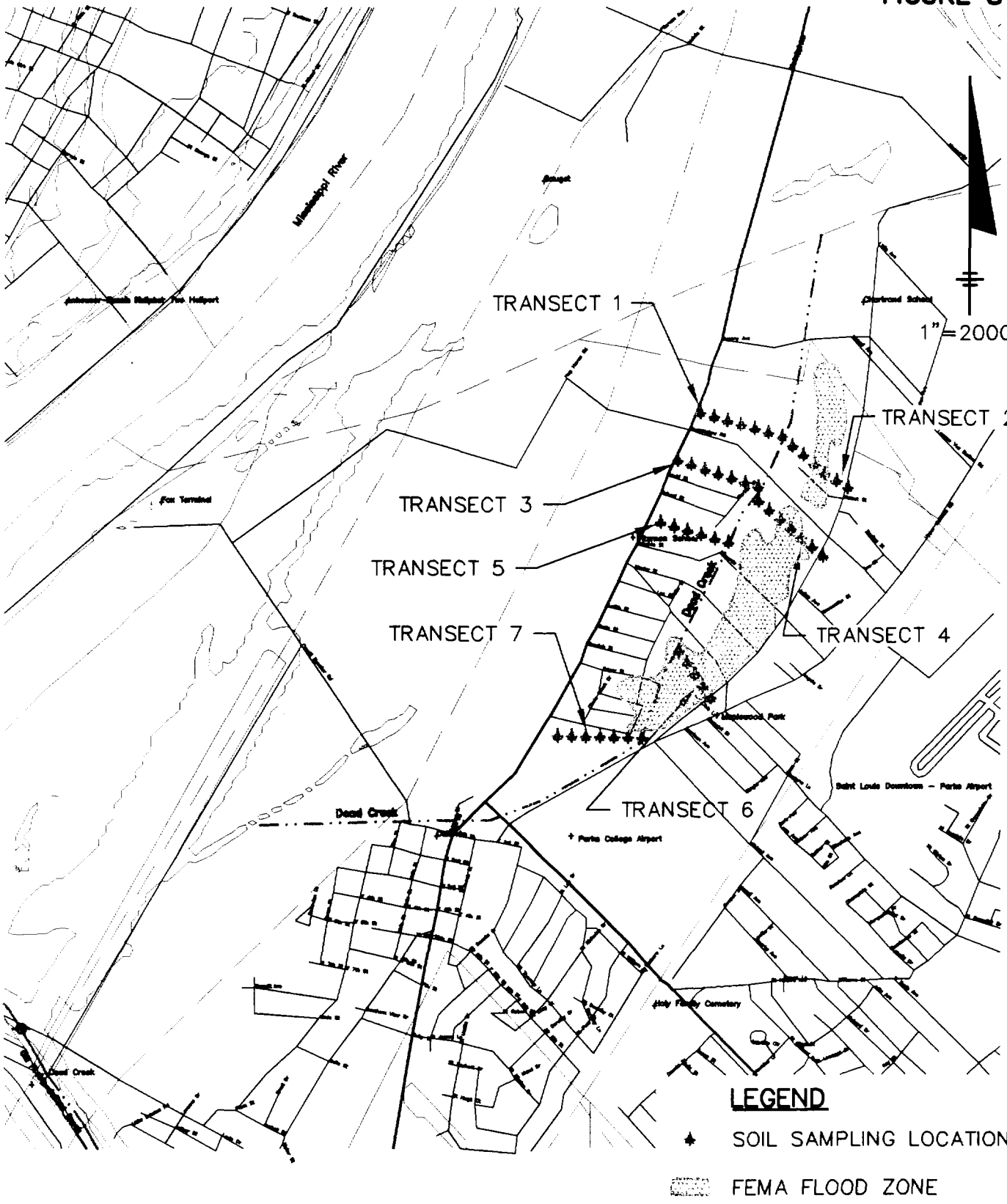
PLOT DATE: 4/2/99

FIGURE 8



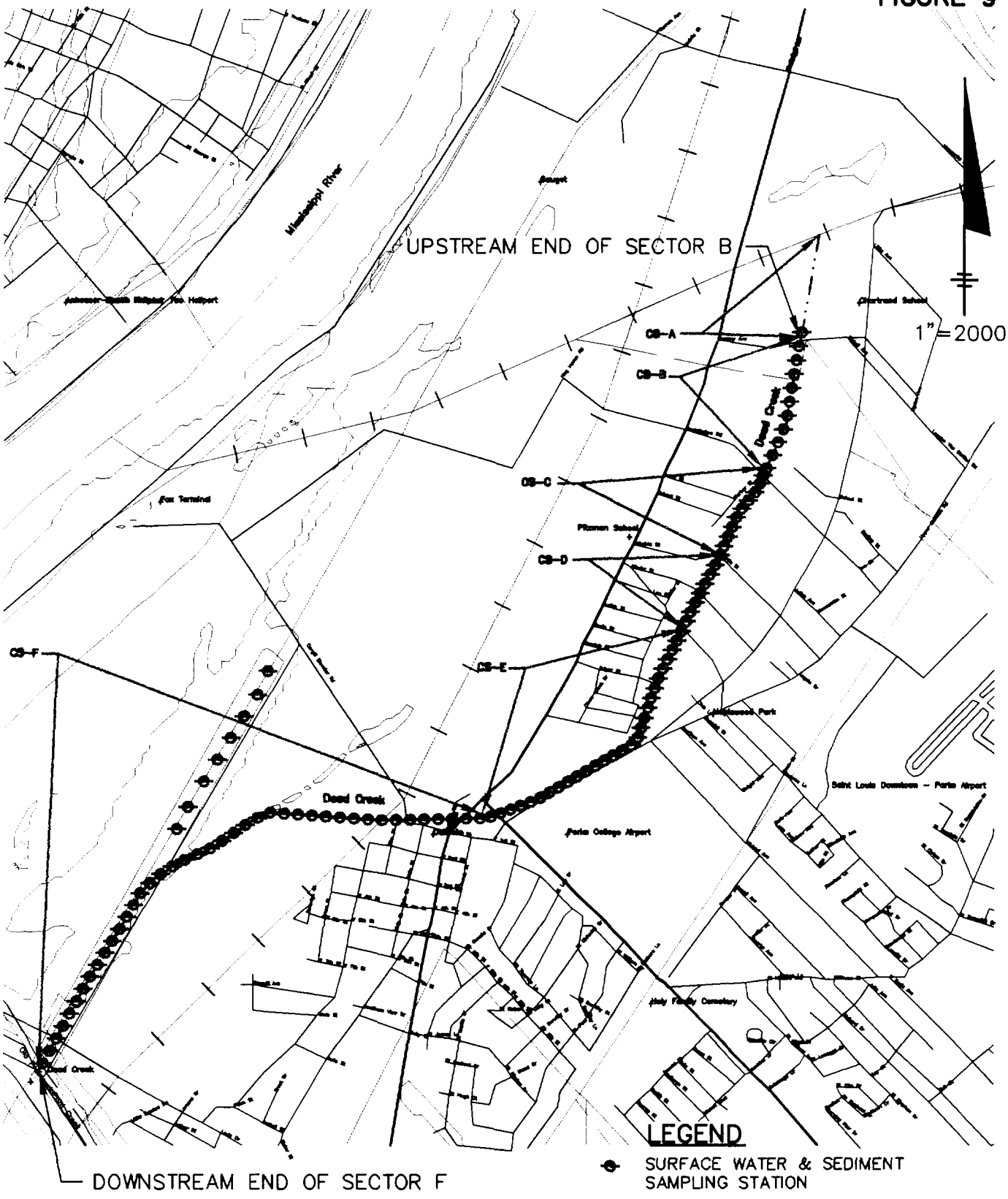
SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET AND CAHOKIA, IL

SOIL SAMPLING LOCATIONS

23548.010.04
3/29/99

O'BRIEN & GERE ENGINEERS INC.

FIGURE 9



SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET AND CAHOKIA, IL

SURFACE WATER & SEDIMENT SAMPLING LOCATIONS
INDUSTRY-SPECIFIC CONSTITUENT MIGRATION

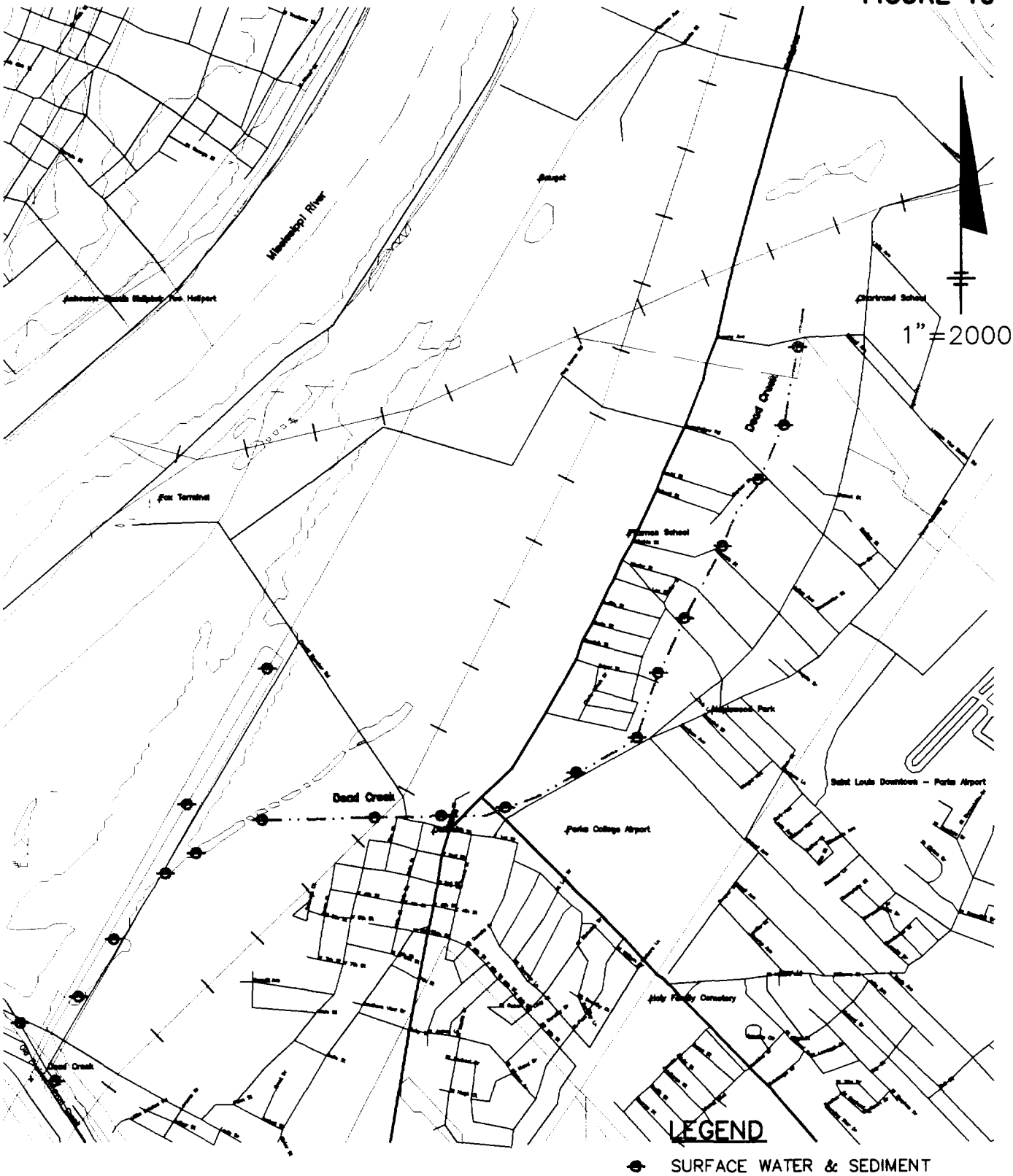
23548.010.03
3/29/99

OBRIEN & GERE ENGINEERS INC.

DWG PATH: I:\10040\23548\DWG\03.DWG 1=2000

PLOT DATE: 4/2/99

FIGURE 10



SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET AND CAHOKIA, IL

SURFACE WATER & SEDIMENT SAMPLING LOCATIONS
SITE-SPECIFIC CONSTITUENT MIGRATION

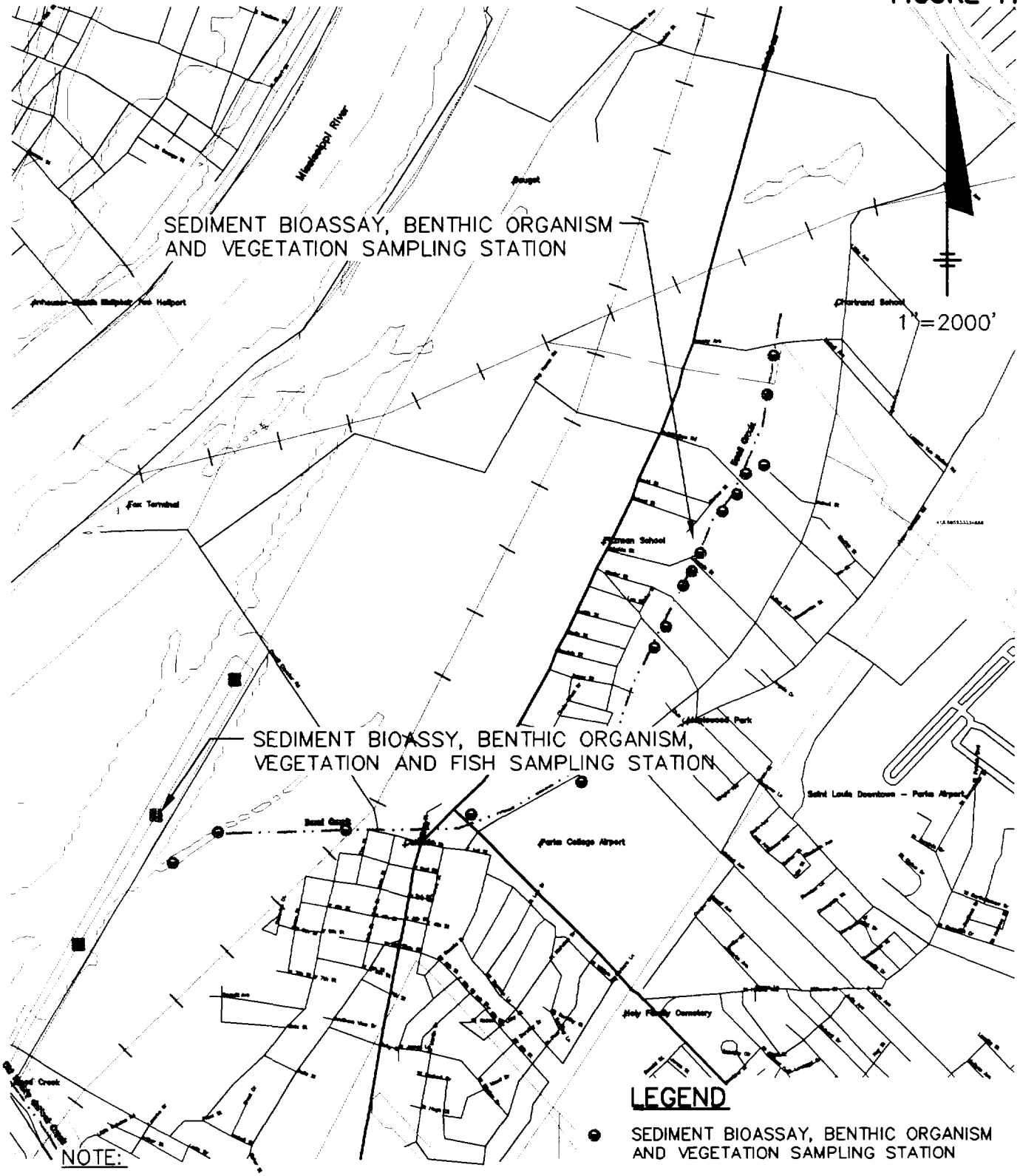
23548.010.02
3/29/99

CRAWFORD, MURPHY & TILLY ENGINEERS INC.

DWG PATH: I:\10040\23548\DWG\02.DWG 1=2000

PLOT DATE: 4/2/99

FIGURE 11



NOTE:
REFERENCE AREA 1 AND 2 NOT SHOWN ON FIGURE.

SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET AND CAHOKIA, IL

ECOLOGICAL SAMPLING LOCATIONS

23548.010.01
3/29/99

O'BRIEN & GERE ENGINEERS INC.

DWG PATH: I:\10040\23548\DWG\01.DWG 1=2000

PLOT DATE: 3/29/99

APPENDICES

Appendix A

Static head space gas chromatography standard operating procedure (SOP)

STATIC HEADSPACE GAS CHROMATOGRAPHY

I. SCOPE AND APPLICATION

A. This method closely parallels EPA Method 3810 and is a static headspace technique for extracting volatile organic compounds (VOCs) from samples. It is a method that allows large numbers of samples to be screened in a relatively short period of time. Detection limits for this method may vary widely among samples because of the large variability and complicated matrices of waste samples. The method works best for compounds with boiling points of less than 125°C. The sensitivity of this method will depend on the equilibria of the various compounds between the vapor and dissolved phases.

B. Data generated by this method is ideal for characterizing the nature and extent of VOCs in soils and groundwaters.

II. SUMMARY OF METHOD

A. The sample is collected in a sealed glass container and allowed to equilibriate at 90°C. A sample of the headspace gas is withdrawn with a gas-tight syringe for analysis by gas chromatography (G.C.).

III. INTERFERENCES

A. Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. To reduce carryover, the sample syringe must be thoroughly cleaned between samples.

B. Before processing any samples, the analyst should demonstrate daily through the analysis of an organic-free water or solvent blank that the entire analytical system is interference-free.

IV. APPARATUS AND MATERIALS

A. Vials: 40 ml vials with open top screw caps and teflon/silicone septa.

B. Gas Chromatograph: Shimadzu GC-14A or equivalent lab-grade unit.

C. Data System: Shimadzu CR4A or equivalent.

D. Detectors: Flame ionization and/or electron capture.

E. Column: Restek 502.2, 624, or equivalent middle-polarity phase.

F. Syringes: Hamilton syringes including 10-μL and 500-μL gas-tight.

G. Heating block.

V. PROCEDURE

A. Gas chromatographic conditions and calibration.

1. The following conditions are provided as a guide; optimum performance will depend on analytes of interest:

   a. Oven Temperature Program: 70°C (5 min) → 10°C/min → 190°C (5 min)
   b. Injector Temp = 275°C
   c. Detector Temp = 290°C
   d. Carrier Gas = Nitrogen @ 19 ml/min (for 105m column)
   e. Injection Amount = 350μL
   f. Initial calibration should consist of at least three concentration levels for each target analyte.

B. Sample preparation and analysis.

1. Soil sample

   Place 20.0 g soil sample into a vial.
   Add 20.0 ml DI H_2O (shown to be free of contamination) to vial and soil.
   Shake for 1 minute.

   or

   Groundwater sample

   Place 20.0 ml groundwater sample into a vial.

2. Place sample vial in heating block at 90°C for 1 hour.

3. Withdraw 350 μL of the headspace with a gas-tight syringe and analyze by direct injection into the G.C.

VI. QUALITY CONTROL

A. A three (or five) point calibration curve must be set-up before samples are analyzed.

B. A method blank must be analyzed at the start of each day and at a rate of one per every 10 samples to show the system is interference-free.

C. A continuing calibration check must be analyzed at the start of each day and at a rate of one per every 10 samples to verify that the operation of the measurement system is in control and not varying.

Appendix B

Sample chain-of-custody form

Figure 1. *Example chain-of-custody*

Project Name:Support Sampling , Sauget Area 1 Site, Solutia Inc.
Job No. _____
Sheet ____ of ____

Office: _____
Address: _____
Phone: _____

CHAIN OF CUSTODY

Cooler Temperature _____

CLIENT: LOCATION:			COLLECTED BY: (Signature)				
SAMPLE DESCRIPTION/LOCATION	Date	Time	Sample Matrix[1]	Sample Type[2]	No. of Containers	ANALYSIS REQUESTED[3]	Sample Preservation

[1] Matrix = Ground water, surface water, sediment, biota [3] VOC - USEPA 8260, 8270, 6010 [2]Type = grab, composite

Relinquished by: _____ of: _____	Date	Time	Received by: _____ of: _____	Date	Time
Relinquished by: _____ of: _____	Date	Time	Received by: _____ of: _____	Date	Time
Relinquished by: _____ of: _____	Date	Time	Received by: _____ of: _____	Date	Time
Use this space if shipped via courier (e.g., Fed Ex) Relinquished by: _____ of: _____	Date	Time	Courier Name and Airbill Number: _____ _____ ***Attach delivery/courier receipt to Chain of Custody**	Date	Time
Relinquished by: _____ of: _____	Date	Time	Received by: _____ of: _____	Date	Time

Appendix C

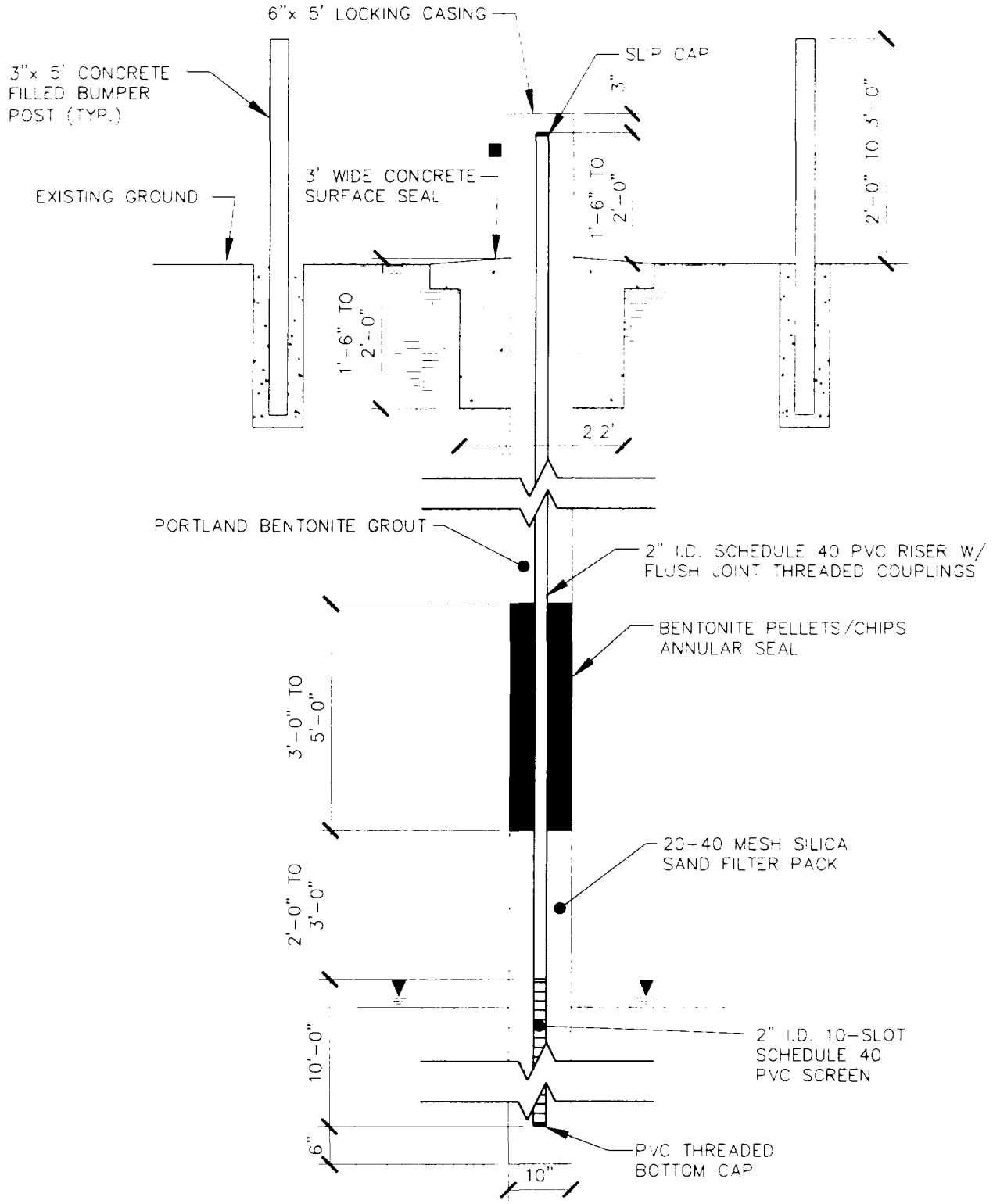
Test boring log

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	REPORT OF BORING
Client:	Sampler:	Page 1 of Location:
)j. Loc:	Hammer:	Start Date:
File No.:	Fall:	End Date:
Boring Company: Foreman: OBG Geologist:		Screen = Riser \ Grout Sand Pack Bentonite

Depth Below Grade	No.	Depth (feet)	Blows /6"	Penetr/ Recovery	"N" Value	Sample Description	Stratum Change General Descript	Equip. Installed	Field Testing HNU (ppm	

Appendix D

Typical well construction diagrams



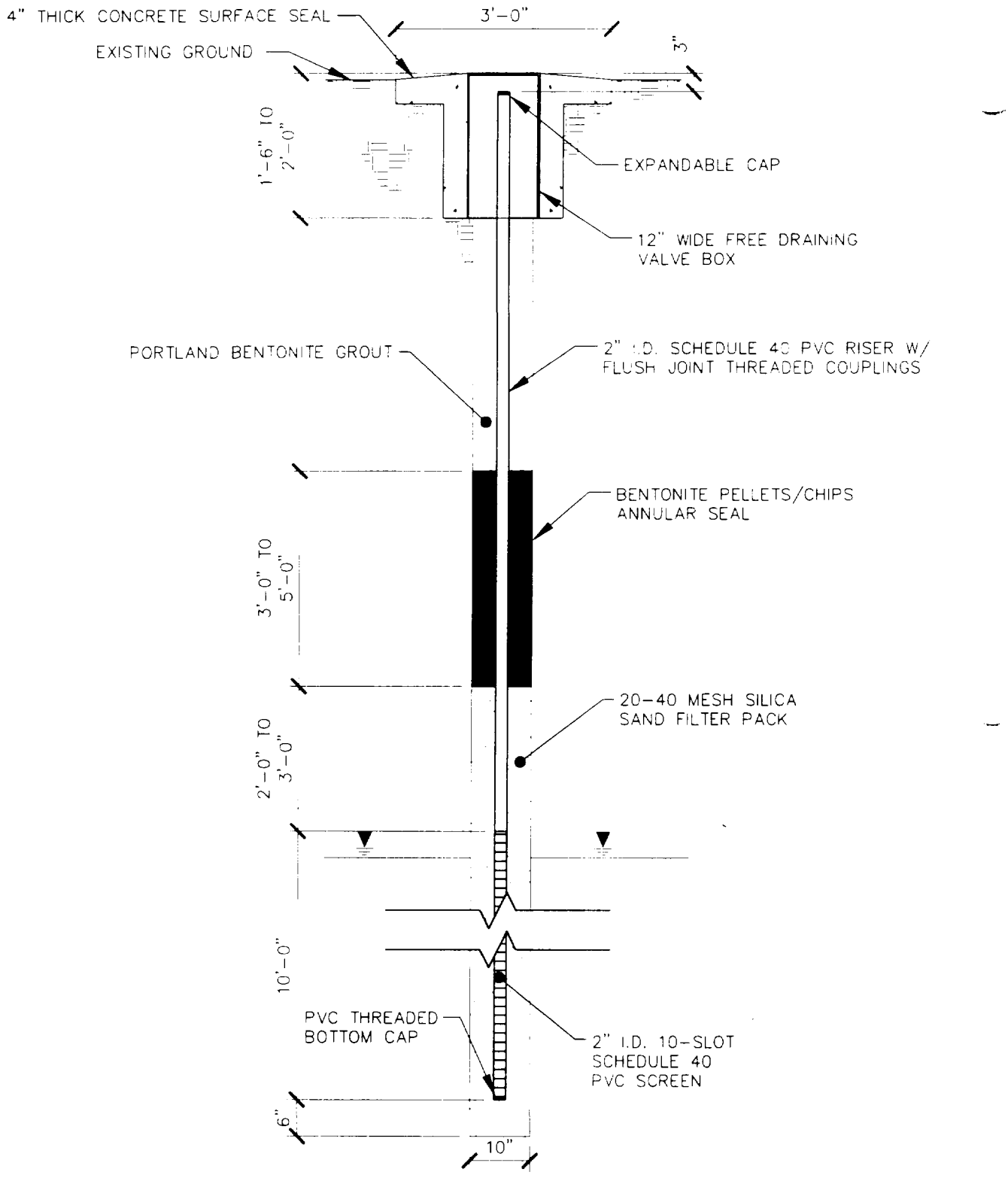
SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET & CAHOKIA, IL

TYPICAL ABOVEGROUND MONITORING WELL CONSTRUCTION DIAGRAM

23548.010.15
4/5/99

O'BRIEN & GERE ENGINEERS, INC.

DWG PATH: I:\PROJECTS\10040\23548\DWG\12.DWG 1=24



SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET & CAHOKIA, IL

TYPICAL FLUSH-MOUNT MONITORING WELL CONSTRUCTION DIAGRAM

23548.010.13
4/2/99

O'BRIEN & GERE ENGINEERS INC

PLOT DATE: 4/2/99

Appendix E

Ground water sampling log

O'BRIEN & GERE ENGINEERS, INC. — Ground Water Sampling Log

'ate:
.te Name:
Site Location
Personnel:

Weather:
Well Number:
Project Number:
Evacuation Method:

Depth of Well * ____ ft.
Depth to Water * ____ ft.
Length of Water Column ____ ft.
Volume of Water in Well ____ gal.(s)
3X Volume of Water in Well ____ gal.(s)

Water Volume /ft. for:
2" Diameter Well = 0.163 X LWC
4" Diameter Well = 0.653 X LWC
6" Diameter Well = 1.469 X LWC

Volume removed before sampling ____ gal.(s)
Did well go dry? Yes ____ No ____

*Measurements taken from ____ Top of Well Casing ____ Top of Protective Casing ____ (Other, Specify)

Water parameters:

Temperature Reading		pH Reading		Conductivity Reading	
	initial	4.0 Standard		84 S Standard	
		7.0 Standard		1413 S Standard	
		10.0 Standard		initial	
	initial	initial		after ____ (gal.)	
after ____ (gal.)		after ____ (gal.)		after ____ (gal.)	
after ____ (gal.)		after ____ (gal.)		after ____ (gal.)	
after ____ (gal.)		after ____ (gal.)		after ____ (gal.)	
after ____ (gal.)		after ____ (gal.)		after ____ (gal.)	
after ____ (gal.)		after ____ (gal.)		after ____ (gal.)	

Water Sample:
Time Collected: ____

hysical Appearance at Start		Physical Appearance at Sampling	
Color		Color	
Odor		Odor	
Turbidity (> 100 NTUs)		Turbidity (> 100 NTU's)	
Sheen/Free Product		Sheen/Free Product	

Sample Parameters:

Container Size	Container Type	# Collected	Filtered	Preservative	pH	Temp.	Conductivity

Monitoring Well Integrity Checklist:

Well identification number clearly marked?	Yes ____	No ____
Well covers and locks in good condition and secure?	Yes ____	No ____
Is the well stand pipe vertically aligned and secure?	Yes ____	No ____
Is the concrete pad and surface seal in good condition?	Yes ____	No ____
Are soils surrounding the well pad eroded?	Yes ____	No ____
Is the PVC well casing in good condition?	Yes ____	No ____
Is there standing water in the annular space between the well stand pipe and PVC casing?	Yes ____	No ____
s the stand pipe vented at the base to provide drainage?	Yes ____	No ____
Does the total depth of the well sounded correspond with original well completion depths?	Yes ____	No ____

NOTES: Top of casing elevation: ____
Depth to Ground Water: ____
Ground Water Elevation: ____

Appendix F

Slug test field log

O'Brien & Gere Engineers, Inc. **Slug Test Field Log**

Project Number:_____

Date:_____ Site Name:_____ Site Location:_____

Personnel:_____ Weather:_____ Piezometer:_____

_____

Slug type: _____solid PVC length_____ft _____water length_____ft
_____compressed air

Transducer: type:_____ serial #:__ _____ depth set below top of casing:_____

Data Logger: manufacturer:_____ model #:_____ serial #:_____

Timing device: manufacturer:_____ model#:_____ serial #:_____

Test Objective:_____

Test Limitations:_____

Correlatable Data Bases:_____

Piezometer Condition:_____ obstructions:_____ siltation:_____

Screen Interval: depth to top of screen from top of casing:_____ft screen length:_____ft
screened lithology:_____

Static Head: initial:_____ft with transducer:_____ft
(below top of casing)

Total depth of piezometer:_____ft Length of water column:_____ft
screen fully submerged:_____ partially submerged:_____

Test Method: _____rising head _____falling head

Head Change: feet of head change during test:_____ft sufficient for test:_____yes _____no

Data Logging Interval(s), in seconds or minutes: early_____ middle_____ end_____

Well Recovery % at end of test:_____%

Was preliminary data evaluation completed? _____yes _____no

Was the instantaneous head change sufficient to observe a meaningful water level response? _____yes _____no

Were sufficient data points collected to define the water level recovery for the slug test? _____yes _____no

Is the test consistent with pre-test expectations? ____yes _____no

Was the slug test successful? _____yes _____no

Test data copied to disk and labeled:____ yes _____no filename:_____

If the test was not succesful, reevaluate test design and complete new test.

Appendix G

Air sampling methods

METHOD TO-1

Revision 1.0
April, 1984

METHOD FOR THE DETERMINATION OF VOLATILE ORGANIC COMPOUNDS IN AMBIENT AIR USING TENAX® ADSORPTION AND GAS CHROMATOGRAPHY/MASS SPECTROMETRY (GC/MS)

1. Scope

1.1 The document describes a generalized protocol for collection and determination of certain volatile organic compounds which can be captured on Tenax® GC (poly(2,6-Diphenyl phenylene oxide)) and determined by thermal desorption GC/MS techniques. Specific approaches using these techniques are described in the literature (1-3).

1.2 This protocol is designed to allow some flexibility in order to accommodate procedures currently in use. However, such flexibility also results in placement of considerable responsibility with the user to document that such procedures give acceptable results (i.e., documentation of method performance within each laboratory situation is required). Types of documentation required are described elsewhere in this method.

1.3 Compounds which can be determined by this method are nonpolar organics having boiling points in the range of approximately 80° - 200°C. However, not all compounds falling into this category can be determined. Table 1 gives a listing of compounds for which the method has been used. Other compounds may yield satisfactory results but validation by the individual user is required.

2. Applicable Documents

2.1 ASTM Standards:

D1356	Definitions of Terms Related to Atmospheric Sampling and Analysis.
E355	Recommended Practice for Gas Chromatography Terms and Relationships.

2.2 Other documents:

Existing procedures (1-3).

U. S. EPA Technical Assistance Document (4).

3. Summary of Protocol

3.1 Ambient air is drawn through a cartridge containing ~1-2 grams of Tenax and certain volatile organic compounds are trapped on the resin while highly volatile organic compounds and most inorganic atmospheric constituents pass through the cartridge. The cartridge is then transferred to the laboratory and analyzed.

3.2 For analysis the cartridge is placed in a heated chamber and purged with an inert gas. The inert gas transfers the volatile organic compounds from the cartridge onto a cold trap and subsequently onto the front of the GC column which is held at low temperature (e.g., -70°C). the GC column temperature is then increased (temperature programmed) and the components eluting from the column are identified and quantified by mass spectrometry. Component identification is normally accomplished, using a library search routine, on the basis of the GC retention time and mass spectral characteristics. Less sophisticated detectors (e.g., electron capture or flame ionization) may be used for certain applications but their suitability for a given application must be verified by the user.

3.3 Due to the complexity of ambient air samples only high resolution (i.e., capillary) GC techniques are considered to be acceptable in this protocol.

4. Significance

4.1 Volatile organic compounds are emitted into the atmosphere from a variety of sources including industrial and commercial facilities, hazardous waste storage facilities, etc. Many of these compounds are toxic; hence knowledge of the levels of such materials in the ambient atmosphere is required in order to determine human health impacts.

4.2 Conventional air monitoring methods (e.g., for workspace monitoring) have relied on carbon adsorption approaches with subsequent solvent desorption. Such techniques allow subsequent injection of only a small portion, typically 1-5% of the sample onto the GC system. However, typical ambient air concentrations of these compounds require a more sensitive approach. The thermal

desorption process, wherein the entire sample is introduced into the analytical (GC/MS) system fulfills this need for enhanced sensitivity.

5. Definitions

Definitions used in this document and any user prepared SOPs should be consistent with ASTM D1356(6). All abbreviations and symbols are defined with this document at the point of use.

6. Interferences

6.1 Only compounds having a similar mass spectrum and GC retention time compared to the compound of interest will interface in the method. The most commonly encountered interferences are structural isomers.

6.2 Contamination of the Tenax cartridge with the compound(s) of interest is a commonly encountered problem in the method. The user must be extremely careful in the preparation, storage, and handling of the cartridges throughout the entire sampling and analysis process to minimize this problem.

7. Apparatus

7.1 Gas Chromatograph/Mass Spectrometry system - should be capable of subambient temperature programming. Unit mass resolution or better up to 800 amu. Capable of scanning 30-400 amu region every 0.5-1 second. Equipped with data system for instrument control as well as data acquisition, processing and storage.

7.2 Thermal Desorption Unit - Designed to accommodate Tenax cartridges in use. See Figure 2a or b.

7.3 Sampling System - Capable of accurately and precisely drawing an air flow of 10-500 ml/minute through the Tenax cartridge. (See Figure 3a or b.)

7.4 Vacuum oven - connected to water aspirator vacuum supply.

7.5 Stopwatch.

7.6 Pyrex disks - for drying Tenax.

7.7 Glass jar - Capped with Teflon-lined screw cap. For storage of purified Tenax.

7.8 Powder funnel - for delivery of Tenax into cartridges.

7.9 Culture tubes - to hold individual glass Tenax cartridges.

7.10 Friction top can (paint can) - to hold clean Tenax cartridges.

7.11 Filter holder - stainless steel or aluminum (to accommodate 1 inch diameter filter). Other sizes may be used if desired. (optional)

7.12 Thermometer - to record ambient temperature.

7.13 Barometer (optional).

7.14 Dilution bottle - Two-liter with septum cap for standards preparation.

7.15 Teflon stirbar - 1 inch long.

7.16 Gas-tight glass syringes with stainless steel needles - 10-500 µl for standard injection onto GC/MS system.

7.17 Liquid microliter syringes - 5.50 µL for injecting neat liquid standards into dilution bottle.

7.18 Oven - 60 $\pm$ 5°C for equilibrating dilution flasks.

7.19 Magnetic stirrer.

7.20 Heating mantel.

7.21 Variac

7.22 Soxhlet extraction apparatus and glass thimbles - for purifying Tenax.

7.23 Infrared lamp - for drying Tenax.

7.24 GC column - SE-30 or alternative coating, glass capillary or fused silica.

7.25 Psychrometer - to determine ambient relative humidity. (optional)

8. Reagents and Materials

8.1 Empty Tenax cartridges - glass or stainless steel (see Figure 1a or b).

8.2 Tenax 60/80 mesh (2,6-diphenylphenylene oxide polymer).

8.3 Glasswool - silanized.

8.4 Acetone - Pesticide quality or equivalent.

8.5 Methanol - Pesticide quality or equivalent.

8.6 Pentane - Pesticide quality or equivalent.

8.7 Helium - Ultra pure, compressed gas. (99.9999%)

8.8 Nitrogen - Ultra pure, compressed gas. (99.9999%)

8.9 Liquid nitrogen.

8.10 Polyester gloves - for handling glass Tenax cartridges.

8.11 Glass Fiber Filter - one inch diameter, to fit in filter holder. (optional)

8.12 Perfluorotributylamine (FC-43).

8.13 Chemical Standards - Neat compounds of interest. Highest purity available.

8.14 Granular activated charcoal - for preventing contamination of Tenax cartridges during storage.

9. Cartridge Construction and Preparation

9.1 Cartridge Design

9.1.1 Several cartridge designs have been reported in the literature (1-3). The most common (1) is shown in Figure 1a. This design minimizes contact of the sample with metal surfaces, which can lead to decomposition in certain cases. However, a disadvantage of this design is the need to rigorously avoid contamination of the <u>outside</u> portion of the cartridge since the entire surface is subjected to the purge gas stream during the desorption process. Clean polyester gloves must be worn at all

times when handling such cartridges and exposure of the open cartridge to ambient air must be minimized.

9.1.2 A second common type of design (3) is shown in Figure 1b. While this design uses a metal (stainless steel) construction, it eliminates the need to avoid direct contact with the exterior surface since only the interior of the cartridge is purged.

9.1.3 The thermal desorption module and sampling system must be selected to be compatible with the particular cartridge design chosen. Typical module designs are shown in Figure 2a and b. These designs are suitable for the cartridge designs shown in Figures 1a and b, respectively.

9.2 Tenax Purification

9.2.1 Prior to use the Tenax resin is subjected to a series of solvent extraction and thermal treatment steps. The operation should be conducted in an area where levels of volatile organic compounds (other than the extraction solvents used) are minimized.

9.2.2 All glassware used in Tenax purification as well as cartridge materials should be thoroughly cleaned by water rinsing followed by an acetone rinse and dried in an oven at 250°C.

9.2.3 Bulk Tenax is placed in a glass extraction thimble and held in place with a plug of clean glasswool. The resin is then placed in the soxhlet extraction apparatus and extracted sequentially with methanol and then pentane for 16-24 hours (each solvent) at approximately 6 cycles/hour. Glasswool for cartridge preparation should be cleaned in the same manner as Tenax.

9.2.4 The extracted Tenax is immediately placed in an open glass dish and heated under an infrared lamp for two hours in a hood. Care must be exercised to avoid over heating of the Tenax by the infrared lamp. The Tenax is then placed in a vacuum oven (evacuated using a

water aspirator) without heating for one hour. An inert gas (helium or nitrogen) purge of 2-3 ml/minute is used to aid in the removal of solvent vapors. The oven temperature is then increased to 110°C, maintaining inert gas flow and held for one hour. The oven temperature control is then shut off and the oven is allowed to cool to room temperature. Prior to opening the oven, the oven is slightly pressurized with nitrogen to prevent contamination with ambient air. The Tenax is removed from the oven and sieved through a 40/60 mesh sieve (acetone rinsed and oven dried) into a clean glass vessel. If the Tenax is not to be used immediately for cartridge preparation it should be stored in a clean glass jar having a Teflon-lined screw cap and placed in a desiccator.

9.3 Cartridge Preparation and Pretreatment

9.3.1 All cartridge materials are pre-cleaned as described in Section 9.2.2. If the glass cartridge design shown in Figure 1a is employed all handling should be conducted wearing polyester gloves.

9.3.2 The cartridge is packed by placing a 0.5-1cm glasswool plug in the base of the cartridge and then filling the cartridge to within approximately 1 cm of the top. A 0.5-1cm glasswool plug is placed in the top of the cartridge.

9.3.3 The cartridges are then thermally conditioned by heating for four hours at 270°C under an inert gas (helium) purge (100 - 200 ml/min).

9.3.4 After the four hour heating period the cartridges are allowed to cool. Cartridges of the type shown in Figure 1a are immediately placed (without cooling) in clean culture tubes having Teflon-lined screw caps with a glasswool cushion at both the top and the bottom. Each tube should be shaken to ensure that the cartridge is held firmly in place. Cartridges of the type shown in Figure 1b are allowed to cool to room temperature under inert gas purge and are then closed with stainless steel plugs.

9.3.5 The cartridges are labeled and placed in a tightly sealed metal can (e.g., paint can or similar friction top container). For cartridges of the type shown in Figure 1a the culture tube, not the cartridge, is labeled.

9.3.6 Cartridges should be used for sampling within 2 weeks after preparation and analyzed within two weeks after sampling. If possible the cartridges should be stored at -20°C in a clean freezer (i.e., no solvent extracts or other sources of volatile organics contained in the freezer).

10. Sampling

10.1 Flow Rate and Total Volume Selection

10.1.1 Each compound has a characteristic retention volume (liters of air per gram of adsorbent) which must not be exceeded. Since the retention volume is a function of temperature, and possibly other sampling variables, one must include an adequate margin of safety to ensure good collection efficiency. Some considerations and guidance in this regard areprovided in a recent report (5). Approximate breakthrough volumes at 38°C (100°F) in liters/gram of Tenax are provided in Table 1. These retention volume data are supplied only as rough guidance and are subject to considerable variability, depending on cartridge design as well as sampling parameters and atmospheric conditions.

10.1.2 To calculate the maximum total volume of air which can be sampled use the following equation:

$$V_{MAX} = \frac{V_b x W}{1.5}$$

where

V_{MAX} is the calculated maximum total volume in liters.

V_b is the breakthrough volume for the least retained compound of interest (Table 1) in liters per gram of Tenax.

W is the weight of Tenax in the cartridge, in grams.

1.5 is a dimensionless safety factor to allow for variability in atmospheric conditions. This factor is appropriate for temperatures in the range of 25-30°C. If higher temperatures are encountered the factor should be increased (i.e. maximum total volume decreased).

10.1.3 To calculate maximum flow rate use the following equation:

$$Q_{MAX} = \frac{V_{MAX}}{t} x 1000$$

where

Q_{MAX} is the calculated maximum flow rate in milliliters per minute.
t is the desired sampling time in minutes. Times greater than 24 hours (1440 minutes) generally are unsuitable because the flow rate required is too low to be accurately maintained.

10.1.4 The maximum flow rate Q_{MAX} should yield a linear flow velocity of 50-500 cm/minute. Calculate the linear velocity corresponding to the maximum flow rate using the following equation:

$$B = \frac{Q_{MAX}}{\pi r^2}$$

where

B is the calculated linear flow velocity in centimeters per minute.
r is the internal radius of the cartridge in centimeters.

If B is greater then 500 centimeters per minute either the total sample flow rate (V_{MAX}) should be reduced or the sample flow rate (Q_{MAX}) should be reduced by increasing the collection time. If B is less then 50 centimeters per minute the sampling rate (Q_{MAX}) should be increased by reducing the sampling time. The total sample value (V_{MAX}) cannot be increased due to component breakthrough.

10.1.5 The flow rate calculated as described above defines the maximum flow rate allowed. In general, one should collect additional samples in parallel, for the same time period but at lower flow rates. This practice yields a measure of quality control and is further discussed in the literature (5). In general, flow rates 2 to 4 fold lower than the maximum flow rate should be employed for the parallel samples. In all cases a constant flow rate should be achieved for each cartridge since accurate integration of the analyte concentration requires that the flow be constant over the sampling period.

10.2 Sample Collection

10.2.1 Collection of an accurately known volume of air is critical to the accuracy of the results. For this reason the use of mass flow controllers, rather than conventional needle valves or orifices is highly recommended, especially at low flow velocities (e.g., less than 100 milliliters/minute). Figure 3a illustrates a sampling system utilizing mass flow controllers. This system readily allows for collection of parallel samples. Figure 3b shows a commercially available system based on needle valve flow controllers.

10.2.2 Prior to sample collection insure that the sampling flow rate has been calibrated over a range including the rate to be used for sampling, with a "dummy" Tenax cartridge in place. Generally calibration is accomplished using a soap bubble flow meter or calibrated wet test meter. The flow calibration device is connected to the flow exit, assuming the entire flow system is sealed. ASTM Method D3686 describes an appropriate calibration scheme, not requiring a sealed flow system downstream of the pump.

10.2.3 The flow rate should be checked before and after each sample collection. If the sampling interval exceeds four hours the flow rate should be checked at an intermediate point during sampling as well. In general, a rotameter should be included, as shown in Figure 3b, to allow observation of the sampling flow rate without disrupting the sampling process.

10.2.4 To collect an air sample the cartridges are removed from the sealed container just prior to initiation of the collection process. If glass cartridges (Figure 1a) are employed they must be handled only with polyester gloves and should not contact any other surfaces.

10.2.5 A particulate filter and holder are placed on the inlet to the cartridges and the exit end of the cartridge is connected to the sampling apparatus. In many sampling situations the use of a filter is not necessary if only the total concentration of a component is desired. Glass cartridges of the type shown in Figure 1a are connected using teflon ferrules and Swagelok (stainless steel or teflon) fittings. Start the pump and record the following parameters on an appropriate data sheet (Figure 4): data, sampling location, time, ambient temperature, barometric pressure, relative humidity, dry gas meter reading (if applicable), flow rate, rotameter reading (if applicable), cartridge number and dry gas meter serial number.

10.2.6 Allow the sampler to operate for the desired time, periodically recording the variables listed above. Check flow rate at the midpoint of the sampling interval if longer than four hours. At the end of the sampling period record the parameters listed in 10.2.5 and check the flow rate and record the value. If the flows at the beginning and end of the sampling period differ by more than 10% the cartridge should be marked as suspect.

10.2.7 Remove the cartridges (one at a time) and place in the original container (use gloves for glass cartridges). Seal the cartridges or culture tubes in the friction-top can containing a layer of charcoal and package for immediate shipment to the laboratory for analysis. Store cartridges at reduced temperature (e.g., -20°C) before analysis if possible to maximize storage stability.

10.2.8 Calculate and record the average sample rate for each cartridge according to the following equation:

$$Q_A = \frac{Q_1 + Q_2 + \ldots Q_N}{N}$$

where

Q_A = Average flow rate in ml/minute.
Q_1, Q_2, $\ldots Q_N$ = Flow rates determined at beginning, end, and intermediate points during sampling.
N = Number of points averaged.

10.2.9 Calculate and record the total volumetric flow for each cartridge using the following equation:

$$V_m = \frac{T \times Q_A}{1000}$$

where

V_m = Total volume sampled in liters at measured temperature and pressure.
T_2 = Stop time.
T_1 = Start time.
T = Sampling time = $T_2 - T_1$, minutes

10.2.10 The total volume (V_s) at standard conditions, 25°C and 760 mmHg, is calculated from the following equation:

$$V_s = V_m \times \frac{P_A}{760} \times \frac{298}{273 + t_A}$$

where

P_A = Average barometric pressure, mmHg
t_A = Average ambient temperature, °C.

11. GC/MS Analysis

11.1 Instrument Set-up

11.1.1 Considerable variation from one laboratory to another is expected in terms of instrument configuration. Therefore each laboratory must be responsible for verifying that their particular system yields satisfactory results. Section 14 discusses specific performance criteria which should be met.

11.1.2 A block diagram of the typical GC/MS system required for analysis of Tenax cartridges is depicted in Figure 5. The operation of such devices is described in 11.2.4. The thermal desorption module must be designed to accommodate the particular cartridge configuration. Exposure of the sample to metal surfaces should be minimized and only stainless steel, or nickel metal surfaces should be employed. The volume of tubing and fittings leading from the cartridge to the GC column must be minimized and all areas must be well-swept by helium carrier gas.

11.1.3 The GC column inlet should be capable of being cooled to -70°C and subsequently increased rapidly to approximately 30°C. This can be most readily accomplished using a GC equipped with subambient cooling capability (liquid nitrogen) although other approaches such as manually cooling the inlet of the column in liquid nitrogen may be acceptable.

11.1.4 The specific GC column and temperature program employed will be dependent on the specific compounds of interest. Appropriate conditions are described in the literature (1-3). In general a nonpolar stationary phase (e.g., SE-30, OV-1) temperature programmed from 30°C to 200°C at 8°/minute will be suitable. Fused silica bonded phase columns are preferable to glass columns since they are more rugged and can be inserted directly into the MS ion source, thereby eliminating the need for a GC/MS transfer line.

11.1.5 Capillary column dimensions of 0.3 mm ID and 50 meters long are generally appropriate although shorter lengths may be sufficient in many cases.

11.1.6 Prior to instrument calibration or sample analysis the GC/MS system is assembled as shown in Figure 5. Helium purge flows (through the cartridge) and carrier flow are set at approximately 10 ml/minute and 1-2 ml/minute respectively. If applicable, the injector sweep flow is set at 2-4 ml/minute.

11.1.7 Once the column and other system components are assembled and the various flows established the column temperature is increased to 250°C for approximately four hours (or overnight if desired) to condition the column.

11.1.8 The MS and data system are set according to the manufacturer's instructions. Electron impact ionization (70eV) and an electron multiplier gain of approximately 5 x 10^4 should be employed. Once the entire GC/MS system has been setup the system is calibrated as described in Section 11.2. The user should prepare a detailed standard operating procedure (SOP) describing this process for the particular instrument being used.

11.2 Instrument Calibration

11.2.1 Tuning and mass standardization of the MS system is performed according to manufacturer's instructions and relevant information from the user prepared SOP. Perfluorotributylamine should generally be employed for this purpose. The material is introduced directly into the ion source though a molecular leak. The instrumental parameters (e.g., lens voltages, resolution, etc.) should be adjusted to give the relative ion abundances shown in Table 2 as well as acceptable resolution and peak shape. If these approximate relative abundances cannot be achieved, the ion source may require cleaning according to manufacturer's instructions. In the event that the user's instrument cannot achieve these relative ion abundances, but is otherwise operating properly, the user may adopt another set of relative abundances as performance criteria. However, these alternate values must be repeatable on a day-to-day basis.

11.2.2 After the mass standardization and tuning process has been completed and the appropriate values entered into the data system the user should then calibrate the entire system by introducing known quantities of the standard components of interest into the system. Three alternate procedures may be employed for the calibration process including 1) direct syringe injection of dilute vapor phase standards, prepared in a dilution bottle, onto the GC column, 2) injection of dilute vapor phase standards into a carrier gas stream directed through the Tenax cartridge, and 3) introduction of permeation or diffusion tube standards onto a Tenax cartridge. The standards preparation procedures for each of these approaches are described in Section 13. The following paragraphs describe the instrument calibration process for each of these approaches.

11.2.3 If the instrument is to be calibrated by direct injection of a gaseous standard, a standard is prepared in a dilution bottle as described in Section 13.1. The GC column is cooled to -70°C (or, alternately, a portion of the column inlet is manually cooled with liquid nitrogen). The MS and data system is set up for acquisition as described in the relevant user SOP. The ionization filament should be turned off during the initial 2-3 minutes of the run to allow oxygen and other highly volatile components to elute. An appropriate volume (less than 1 ml) of the gaseous standard is injected onto the GC system using an accurately calibrated gas tight syringe. The system clock is started and the column is maintained at -70°C (or liquid nitrogen inlet cooling) for 2 minutes. The column temperature is rapidly increased to the desired initial temperature (e.g., 30°C). The temperature program is started at a consistent time (e.g., four minutes) after injection. Simultaneously the ionization filament is turned on and data acquisition is initiated. After the last component of interest has eluted acquisition is terminated and the data is processed as described in Section 11.2.5. The standard injection process is repeated using different standard volumes as desired.

11.2.4 If the system is to be calibrated by analysis of spiked Tenax cartridges a set of cartridges is prepared as described in Sections 13.2 or 13.3. Prior to analysis the cartridges are stored as described in Section 9.3. If glass cartridges (Figure 1a) are employed care must be taken to avoid direct contact, as described earlier. The GC column is cooled to -70°C, the collection loop is immersed in liquid nitrogen and the desorption module is maintained at 250°C. The inlet valve is placed in the desorb mode and the standard cartridge is placed in the desorption module, making certain that no leakage or purge gas occurs. The cartridge is purged for 10 minutes and then the inlet valve is placed in the inject mode and the liquid nitrogen source removed from the collection trap. The GC column is maintained at -70°C for two minutes and subsequent steps are as described in 11.2.3. After the process is complete the cartridge is removed from the desorption module and stored for subsequent use as described in Section 9.3.

11.2.5 Data processing for instrument calibration involves determining retention times, and integrated characteristic ion intensities for each of the compounds of interest. In addition, for at least one chromatographic run, the individual mass spectra should be inspected and compared to reference spectra to ensure proper instrumental performance. Since the steps involved in data processing are highly instrument specific, the user should prepare a SOP describing the process for individual use. Overall performance criteria for instrument calibration are provided in Section 14. If these criteria are not achieved the user should refine the instrumental parameters and/or operating procedures to meet these criteria.

11.3 Sample Analysis

11.3.1 The sample analysis process is identical to that described in Section 11.2.4 for the analysis of standard Tenax cartridges.

11.3.2 Data processing for sample data generally involves 1) qualitatively determining the presence or absence of each component of interest on the basis of a set of characteristic ions and the retention time using a reverse-search software routine, 2) quantification of each identified component by integrating the intensity of a characteristic ion and comparing the value to that of the calibration standard, and 3) tentative identification of other components observed using a forward (library) search software routine. As for other user specific processes, a SOP should be prepared describing the specific operations for each individual laboratory.

12. Calculations

12.1 Calibration Response Factors

12.1.1 Data from calibration standards is used to calculate a response factor for each component of interest. Ideally the process involves analysis of at least three calibration levels of each component during a given day and determination of the response factor (area/nanogram injected) from the linear least squares fit of a plot of nanograms injected versus area (for the characteristic ion). In general quantities of component greater than 1000 nanograms should not be injected because of column overloading and/or MS response nonlinearity.

12.1.2 In practice the daily routine may not always allow analysis of three such calibration standards. In this situation calibration data from consecutive days may be pooled to yield a response factor, provided that analysis of replicate standards of the same concentration are shown to agree within 20% on the consecutive days. One standard concentration, near the midpoint of the analytical range of interest, should be chosen for injection every day to determine day-to-day response reproducibility.

12.1.3 If substantial nonlinearity is present in the calibration curve a nonlinear least squares fit (e.g., quadratic) should be employed. This process involves fitting the data to the following equation:

$$Y=A+BX+CX^2$$

where

Y = peak area
X = quantity of component, nanograms
A, B, and C are coefficients in the equation

12.2 Analyte Concentrations

12.2.1 Analyte quantities on a sample cartridge are calculated from the following equation:

$$Y_A=A+BX_A+CX_A$$

where

Y_A is the area of the analyte characteristic ion for the sample cartridge.
X_A is the calculated quantity of analyte on the sample cartridge, in nanograms.
A, B, and C are the coefficients calculated from the calibration curve described in Section 12.1.3.

12.2.2 If instrumental response is essentially linear over the concentration range of interest a linear equation (C=O in the equation above) can be employed.

12.2.3 Concentration of analyte in the original air sample is calculated from the following equation:

$$C_A=\frac{X_A}{V_S}$$

where

C_A is the calculated concentration of analyte in nanograms per liter.
V_S and X_A are as previously defined in Section 10.2.10 and 12.2.1, respectively.

13. Standard Preparation

13.1 Direct Injection

13.1.1 This process involves preparation of a dilution bottle containing the desired concentrations of compounds of interest for direct injection onto the GC/MS system.

13.1.2 Fifteen three-millimeter diameter glass beads and a one-inch Teflon stirbar are placed in a clean two-liter glass septum capped bottle and the exact volume is determined by weighing the bottle before and after filling with deionized water. The bottle is then rinsed with acetone and dried at 200°C.

13.1.3 The amount of each standard to be injected into the vessel is calculated from the desired injection quantity and volume using the following equation:

$$W_T = \frac{W_I}{V_I} \times V_B$$

where

W_T is the total quantity of analyte to be injected into the bottle in milligrams

W_I is the desired weight of analyte to be injected onto the GC/MS system or spiked cartridge in nanograms

V_I is the desired GC/MS or cartridge injection volume (should not exceed 500) in microliters.

V_B is total volume of dilution bottle determined in 13.1.1, in liters.

13.1.4 The volume of the neat standard to be injected into the dilution bottle is determined using the following equation:

$$V_T = \frac{W_T}{d}$$

where

V_T is the total volume of neat liquid to be injected in microliters.

d is the density of the neat standard in grams per milliliter.

13.1.6 The bottle is placed in a 60°C oven for at least 30 minutes prior to removal of a vapor phase standard.

13.1.7 To withdraw a standard for GC/MS injection the bottle is removed from the oven and stirred for 10-15 seconds. A suitable gas-tight microber syringe, warmed to 60°C, is inserted through the septum cap and pumped three times slowly. The appropriate volume of sample (approximately 25% larger than the desired injection volume) is drawn into the syringe and the volume is adjusted to the exact value desired and then immediately injected over a 5-10 seconds period onto the GC/MS system as described in Section 11.2.3.

13.2 Preparation of Spiked Cartridges by Vapor Phase Injection

13.2.1 This process involves preparation of a dilution bottle containing the desired concentrations of the compound(s) of interest as described in 13.1 and injecting the desired volume of vapor into a flowing inert gas stream directed through a clean Tenax cartridge.

13.2.2 A helium purge system is assembled wherein the helium flow 20-30 mL/minute is passed through a stainless steel Tee fitted with a septum injector. The clean Tenax cartridge is connected downstream of the tee using appropriate Swagelok fittings. Once the cartridge is placed in the flowing gas stream the appropriate volume vapor standard, in the dilution bottle, is injected through the septum as described in 13.1.6. The syringe is flushed several times by alternately filling the syringe with carrier gas and displacing the contents into the flow stream, without removing the syringe from the septum. Carrier flow is maintained through the cartridge for approximately 5 minutes after injection.

13.3 Preparation of Spiked Traps Using Permeation or Diffusion Tubes

13.3.1 A flowing stream of inert gas containing known amounts of each compound of interest is generated according to ASTM Method D3609(6).

Note that a method of accuracy maintaining temperature within ± 0.1°C is required and the system generally must be equilibrated for at least 48 hours before use.

13.3.2 An accurately known volume of the standard gas stream (usually 0.1-1 liter) is drawn through a clean Tenax cartridge using the sampling system described in Section 10.2.1, or a similar system. However, if mass flow controllers are employed they must be calibrated for the carrier gas used in Section

13.3.1 (usually nitrogen). Use of air as the carrier gas for permeation systems is not recommended, unless the compounds of interest are known to be highly stable in air.

13.3.3 The spiked cartridges are then stored or immediately analyzed as in Section 11.2.4.

14. Performance Criteria and Quality Assurance

This section summarizes quality assurance (QA) measures and provides guidance concerning performance criteria which should be achieved within each laboratory. In many cases the specific QA procedures have been described within the appropriate section describing the particular activity (e.g., parallel sampling).

14.1 Standard Operating Procedures (SOPs)

14.1.1 Each user should generate SOPs describing the following activities as they are performed in their laboratory:

1) assembly, calibration, and operation of the sampling system,
2) preparation, handling and storage of Tenax cartridges,
3) assembly and operation of GC/MS system including the thermal desorption apparatus and data system, and
4) all aspects of data recording and processing.

14.1.2 SOPs should provide specific stepwise instructions and should be readily available to, and understood by, the laboratory personnel conducting the work.

14.2 Tenax Cartridges Preparation

14.2.1 Each batch of Tenax cartridges prepared (as described in Section 9) should be checked for contamination by analyzing one cartridge immediately after preparation. While analysis can be accomplished by GC/MS, many laboratories may choose to use GC/FID due to logistical and cost considerations.

14.2.2. Analysis by GC/FID is accomplished as described for GC/MS (Section 11) except for use of FID detection.

14.2.3 While acceptance criteria can vary depending on the components of interest, at a minimum the clean cartridge should be demonstrated to contain less than one fourth of the minimum level of interest for each component. For most compounds the blank level should be less than 10 nanograms per cartridge in order to be acceptable. More rigid criteria may be adopted, if necessary, within a specific laboratory. If a cartridge does not meet these acceptance criteria the entire lot should be rejected.

14.3 Sample Collection

14.3.1 During each sampling event at least one clean cartridge will accompany the samples to the field and back to the laboratory, without being used for sampling, to serve as a field blank. The average amount of material found on the field blank cartridge may be subtracted from the amount found on the actual samples. However, if the blank level is greater than 25% of the sample amount, data for that component must be identified as suspect.

14.3.2 During each sampling event at least one set of parallel samples (two or more samples collected simultaneously) will be collected, preferably at different flow rates as described in Section 10.1. If agreement between parallel samples is not generally within $\pm$ 25% the user should collect parallel samples on a much more frequent basis (perhaps for all sampling points). If a trend of lower apparent concentrations with increasing flow

rate is observed for a set of parallel samples one should consider using a reduced flow rate and longer sampling interval if possible. If this practice does not improve the reproducibility further evaluation of the method performance for the compound of interest may be required.

14.3.3 Backup cartridges (two cartridges in series) should be collected with each sampling event. Backup cartridges should contain less than 20% of the amount of components of interest found in the front cartridges, or be equivalent to the blank cartridge level, whichever is greater. The frequency of use of backup cartridges should be increased if increased flow rate is shown to yield reduced component levels for parallel sampling. This practice will help to identify problems arising from breakthrough of the component of interest during sampling.

14.4 GC/MS Analysis

14.4.1 Performance criteria for MS tuning and mass calibration have been discussed in Section 11.2 and Table 2. Additional criteria may be used by the laboratory if desired. The following sections provide performance guidance and suggested criteria for determining the acceptability of the GC/MS system.

14.4.2 Chromatographic efficiency should be evaluated using spiked Tenax cartridges since this practice tests the entire system. In general a reference compound such as perfluorotoluene should be spiked onto a cartridge at the 100 nanogram level as described in Section 13.2 or 13.3. The cartridge is then analyzed by GC/MS as described in Section 11.4. The perfluorotoluene (or other reference compound) peak is then plotted on an expanded time scale so that its width at 10% of the peak can be calculated, as shown in Figure 6. The width of the peak at 10% height should not exceed 10 seconds. More stringent criteria may be required for certain applications. The asymmetry factor (see Figure 6) should be between 0.8 and 2.0. The asymmetry factor for

any polar or reactive compounds should be determined using the process described above. If peaks are observed that exceed the peak width or asymmetry factor criteria above, one should inspect the entire system to determine if unswept zones or cold spots are present in any of the fittings and are necessary. Some laboratories may choose to evaluate column performance separately by direct injection of a test mixture onto the GC column. Suitable schemes for column evaluation have been reported in the literature (7). Such schemes cannot be conducted by placing the substances onto Tenax because many of the compounds (e.g., acids, bases, alcohols) contained in the test mix are not retained, or degrade, on Tenax.

14.4.3 The system detection limit for each component is calculated from the data obtained for calibration standards. The detection limit is defined as

$$DL = A + 3.3S$$

where

DL is the calculated detection limit in nanograms injected.

A is the intercept calculated in Section 12.1.1 or 12.1.3.

S is the standard deviation of replicate determinations of the lowest level standard (at least three such determinations are required).

In general the detection limit should be 20 nanograms or less and for many applications detection limits of 1-5 nanograms may be required. The lowest level standard should yield a signal to noise ratio, from the total ion current response, of approximately 5.

14.4.4 The relative standard deviation for replicate analyses of cartridges spiked at approximately 10 times the detection limit should be 20% or less. Day to day relative standard deviation should be 25% or less.

14.4.5 A useful performance evaluation step is the use of an internal standard to track system performance. This is accomplished by spiking each cartridge, including blank, sample, and calibration cartridges with approximately 100 nanograms of a compound not generally present in ambient air (e.g., perfluorotoluene). The integrated ion intensity for this compound helps to identify problems with a specific sample. In general the user should calculate the standard deviation of the internal standard response for a given set of samples analyzed under identical tuning and calibration conditions. Any sample giving a value greater than $\pm$ 2 standard deviations from the mean (calculated excluding that particular sample) should be identified as suspect. Any marked change in internal standard response may indicate a need for instrument recalibration.

REFERENCES

1. Krost, K. J., Pellizzari, E. D., Walburn, S. G., and Hubbard, S. A., "Collection and Analysis of Hazardous Organic Emissions", Analytical Chemistry, 54, 810-817, 1982.

2. Pellizzari, E. O. and Bunch, J. E., "Ambient Air Carcinogenic Vapors-Improved Sampling and Analytical Techniques and Field Studies", EPA-600/2-79-081, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 1979.

3. Kebbekus, B. B. and Bozzelli, J. W., "Collection and Analysis of Selected Volatile Organic Compounds in Ambient Air", Proc. Air Pollution Control Assoc., Paper No. 82-65.2. Air Poll. Control Assoc., Pittsburgh, Pennsylvania, 1982.

4. Riggin, R. M., "Technical Assistance Document for Sampling and Analysis of Toxic Organic Compounds in Ambient Air", EPA-600/4-83-027, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 1983.

5. Walling, J. F., Berkley, R. E., Swanson, D. H., and Toth, F. J. "Sampling Air for Gaseous Organic Chemical-Applications to Tenax", EPA-600/7-54-82-059, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 1982.

6. Annual Book of ASTM Standards, Part 11.03, "Atmospheric Analysis", American Society for Testing and Materials, Philadelphia, Pennsylvania.

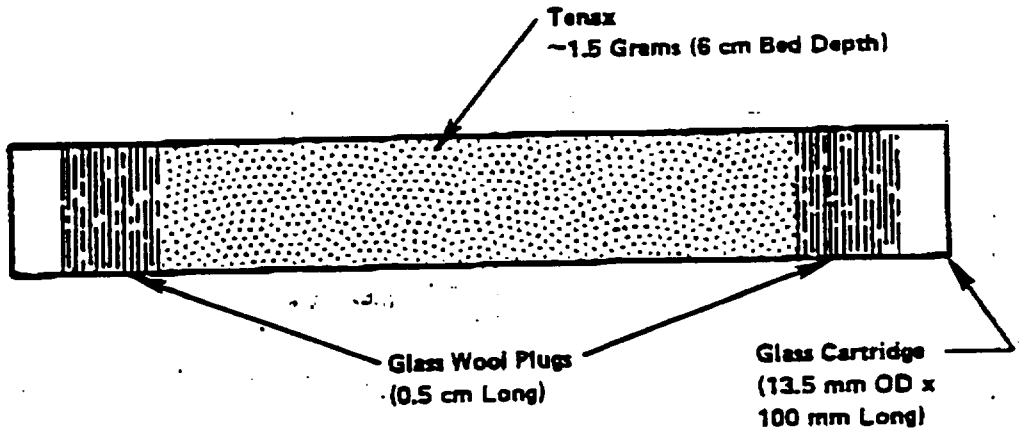
7. Grob, K., Jr., Grob, G., and Grob, K., "Comprehensive Standardized Quality Test for Glass Capillary Columns", J. Chromatog., 156, 1-20, 1978.

TABLE 1. RETENTION VOLUME ESTIMATES FOR COMPOUNDS ON TENAX

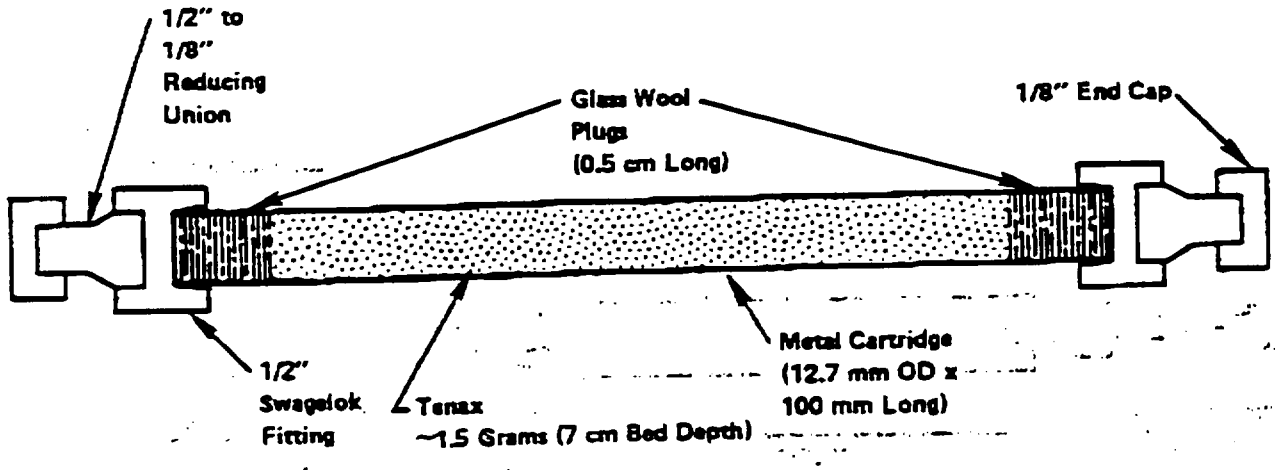
COMPOUND	ESTIMATED RETENTION VOLUME AT 100°F (38°C)-LITERS/GRAM
Benzene	19
Toluene	97
Ethyl Benzene	200
Xylene(s)	~200
Cumene	440
n-Heptane	20
1-Heptene	40
Chloroform	8
Carbon Tetrachloride	8
1,2-Dichloroethane	10
1,1,1-Trichloroethane	6
Tetrachloroethylene	80
Trichloroethylene	20
1,2-Dichloropropane	30
1,3-Dichloropropane	90
Chlorobenzene	150
Bromoform	100
Ethylene Dibromide	60
Bromobenzene	300

TABLE 2. SUGGESTED PERFORMANCE CRITERIA FOR RELATIVE ION ABUNDANCES FROM FC-43 MASS CALIBRATION

M/E	% RELATIVE ABUNDANCE
51	1.8 ± 0.5
69	100
100	12.0 ± 1.5
119	12.0 ± 1.5
131	35.0 ± 3.5
169	3.0 ± 0.4
219	24.0 ± 2.5
264	3.7 ± 0.4
314	0.25 ± 0.1

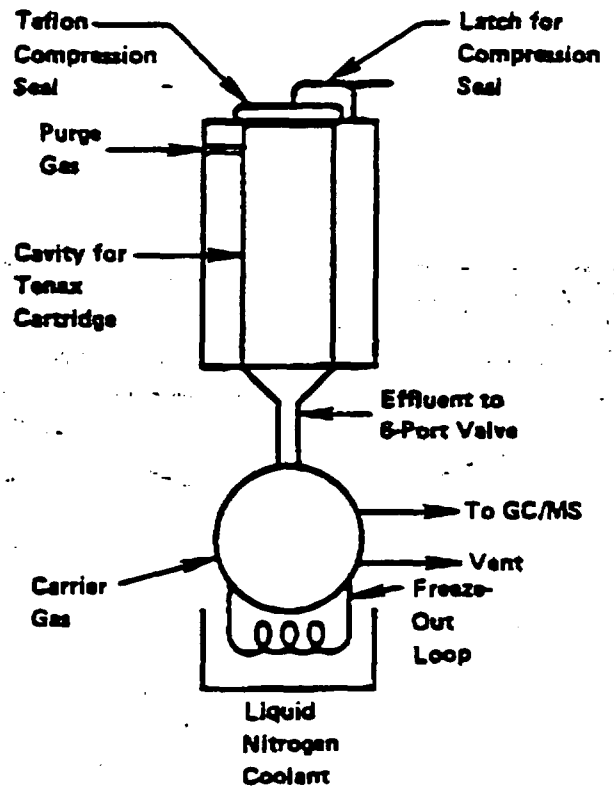


(a) Glass Cartridge

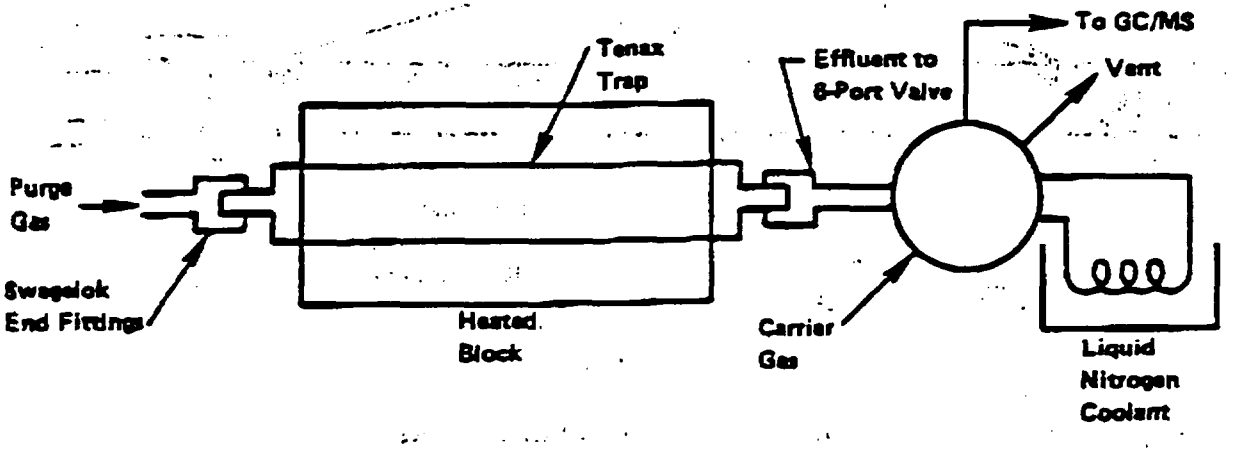


(b) Metal Cartridge

FIGURE 1. TENAX CARTRIDGE DESIGNS

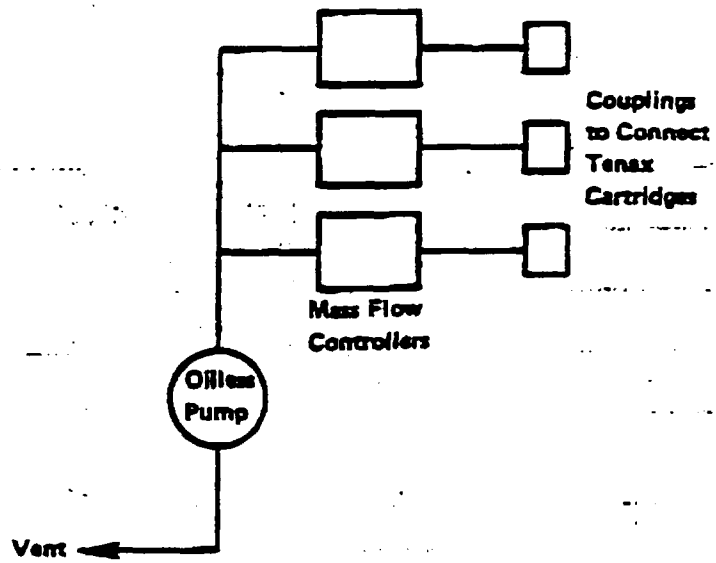


(a) Glass Cartridges (Compression Fit)

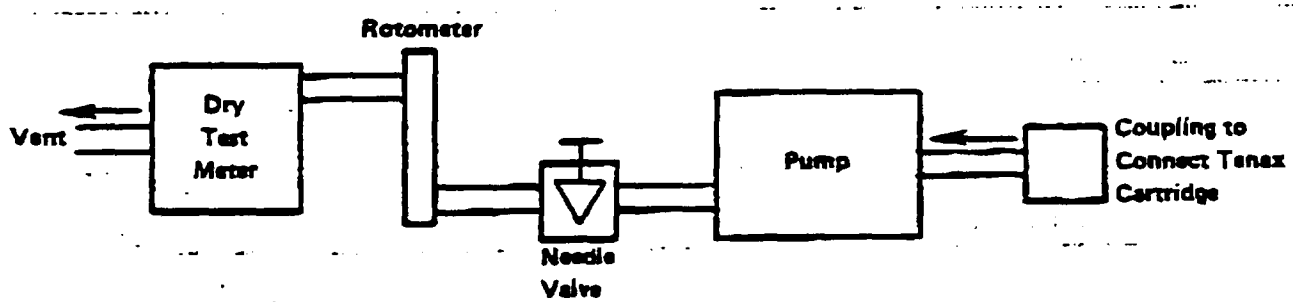


(b) Metal Cartridges (Swagelok Fittings)

FIGURE 2. TENAX CARTRIDGE DESORPTION MODULES



(a) Mass Flow Control



(b) Needle Valve Control

FIGURE 3. TYPICAL SAMPLING SYSTEM CONFIGURATIONS

SAMPLING DATA SHEET
(One Sample Per Data Sheet)

PROJECT: _____ DATE(S) SAMPLED: _____

SITE: _____ TIME PERIOD SAMPLED: _____

LOCATION: _____ OPERATOR: _____

INSTRUMENT MODEL NO: _____ CALIBRATED BY: _____

PUMP SERIAL NO: _____

SAMPLING DATA

Sample Number: _____
Start Time: _____ Stop Time: _____

Time	Dry Gas Meter Reading	Rotameter Reading	Flow Rate, *Q ml/Min	Ambient Temp. °C	Barometric Pressure, mmHg	Relative Humidity, %	Comments
1.							
2.							
3.							
4.							
N.							

Total Volume Data**

V_s = (Final - Initial) Dry Gas Meter Reading, or = _____ Liters

$$= \frac{Q_1 + Q_2 + Q_3 \ldots Q_N}{N} \times \frac{1}{1000 \times (\text{Sampling Time in Minutes})} = \_\_\_\_\_ \text{ Liters}$$

* Flowrate from rotameter or soap bubble calibrator (specify which).
** Use data from dry gas meter if available.

FIGURE 4. EXAMPLE SAMPLING DATA SHEET

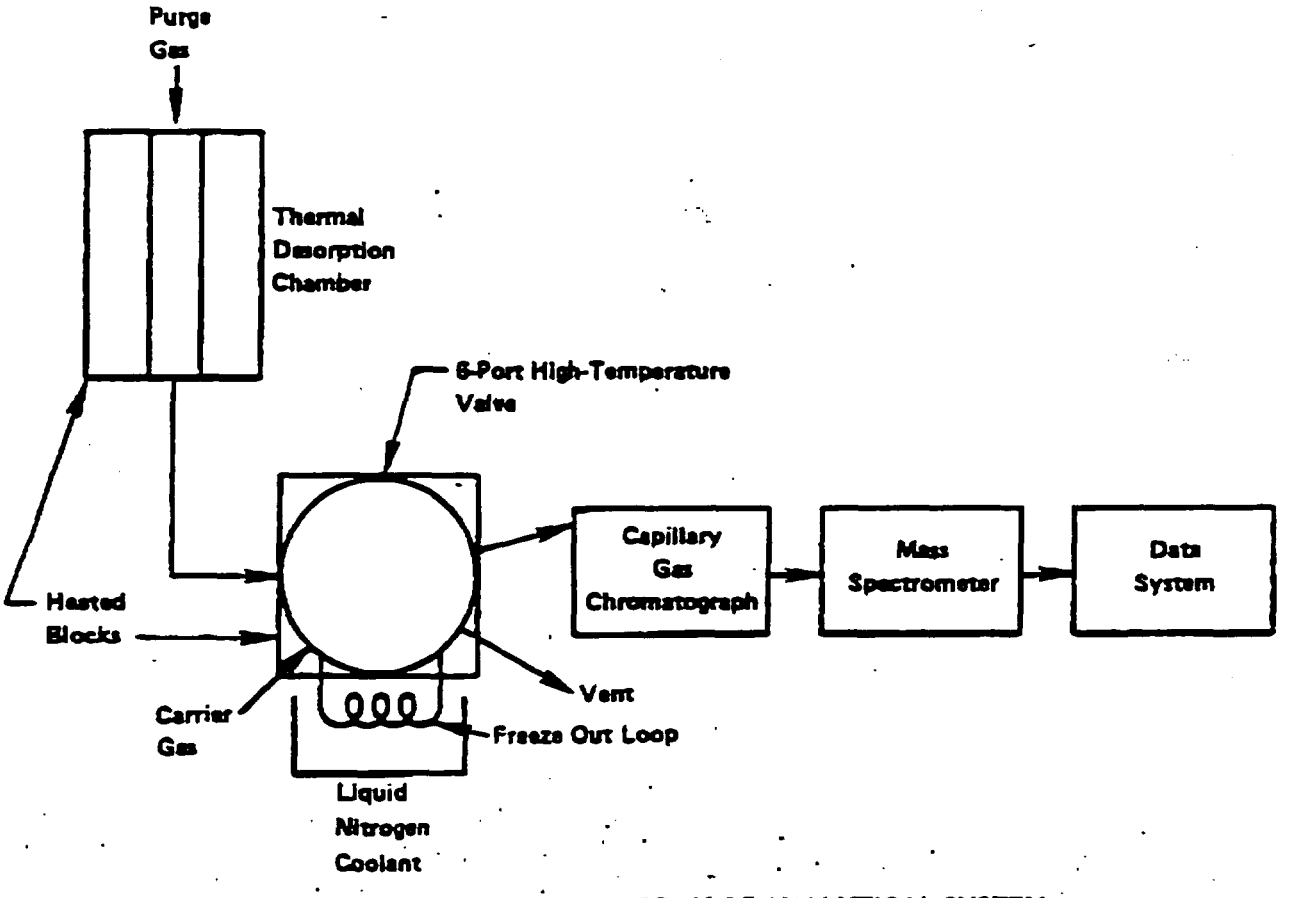
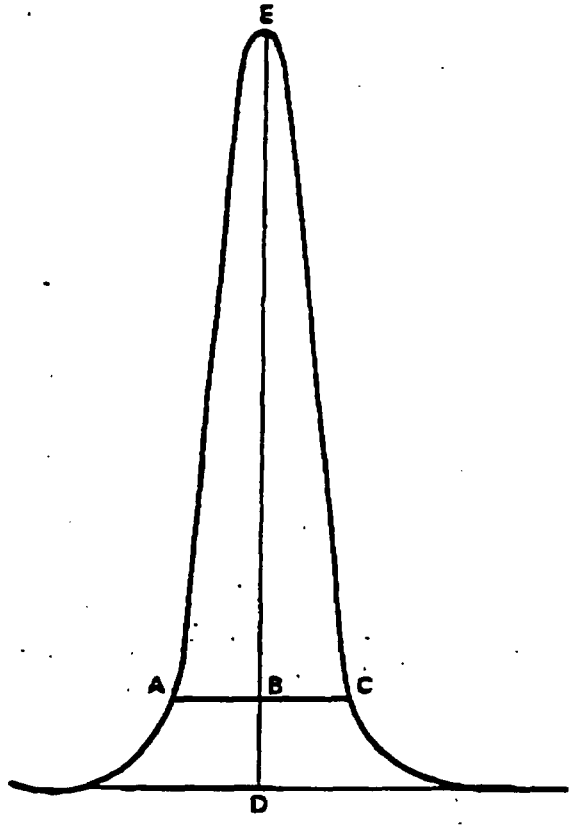


FIGURE 5. BLOCK DIAGRAM OF ANALYTICAL SYSTEM



$$\text{Asymmetry Factor} = \frac{BC}{AB}$$

Example Calculation:

Peak Height = DE = 100 mm
10% Peak Height = BD = 10 mm
Peak Width at 10% Peak Height = AC = 23 mm
AB = 11 mm
BC = 12 mm

Therefore: Asymmetry Factor = $\frac{12}{11}$ = 1.1

FIGURE 6. PEAK ASYMMETRY CALCULATION

METHOD TO4 Revision 1.0
April, 1984

METHOD FOR THE DETERMINATION OF ORGANOCHLORINE PESTICIDES AND POLYCHLORINATED BIPHENYLS IN AMBIENT AIR

1. Scope

1.1 This document describes a method for determination of a variety of organochlorine pesticides and polychlorinated biphenyls (PCBs) in ambient air. Generally, detection limits of >1 ng/m^3 are achievable using a 24-hour sampling period.

1.2 Specific compounds for which the method has been employed are listed in Table 1. Several references are available which provide further details on the development and application of the method. The sample cleanup and analysis methods are identical to those described in U. S. EPA Method 608. That method is included as Appendix A of this methods compendium.

2. Applicable Documents

2.1 ASTM Standards

D1356 Definition of Terms Related to Atmospheric Sampling and Analysis (7).

2.2 Other Documents

Ambient Air Studies (1-3)

U. S. EPA Technical Assistance Document (4).

U. S. EPA Method 608 (5). See Appendix A of methods compendium.

3. Summary of Method

3.1 A modified high volume sampler consisting of a glass fiber filter with a polyurethane foam (PUF) backup absorbent cartridge is used to sample ambient air at a rate of ~200-280 L/minute.

3.2 The filter and PUF cartridge are placed in clean, sealed containers and returned to the laboratory for analysis. The PCBs and pesticides are recovered by Soxhlet extraction with 5% ether in hexane.

3.3 The extracts are reduced in volume using Kuderna-Danish (K-D) concentration techniques and subjected to column chromatographic cleanup.

3.4 The extracts are analyzed for pesticides and PCBs using gas chromatography with electron capture detection (GC-ECD), as described in U. S. EPA Method 608 (5).

4. Significance

4.1 Pesticides, particularly organochlorine pesticides, are widely used in both rural and urban areas for a variety of applications. PCBs are less widely used, due to extensive restrictions placed on their manufacture. However, human exposure to PCBs continues to be a problem because of their presence in various electrical products.

4.2 Many pesticides and PCBs exhibit bioaccumulative, chronic health effects and hence monitoring ambient air for such compounds is of great importance.

4.3 The relatively low levels of such compounds in the environment requires the use of high volume sampling techniques to acquire sufficient sample for analysis. However, the volatility of these compounds prevents efficient collection on filter media. Consequently, this method utilizes both a filter and a PUF backup cartridge which provides for efficient collection of most organochlorine pesticides, PCBs, and many other organics within the same volatility range.

5. Definitions

Definitions used in this document and any user-prepared SOPs should be consistent with ASTM D1356 (7). All abbreviations

and symbols are defined within this document at the point of use.

6. Interferences

6.1 The use of column chromatographic cleanup and selective GC detection (GC-ECD) minimizes the risk of interference from extraneous organic compounds. However, the fact that PCBs as well as certain organochlorine pesticides (e.g. toxaphene and chlordane) are complex mixtures of individual compounds can cause difficulty in accurately quantifying a particular formulation in a multiple component mixture.

6.2 Contamination of glassware and sampling apparatus with traces of pesticides or PCBs can be a major source of error in the method, particularly when sampling near high level sources (e.g. dumpsites, waste processing plants, etc.) careful attention to cleaning and handling procedures is required in all steps of the sampling and analysis to minimize this source of error.

7. Apparatus

7.1 Hi-Vol Sampler with PUF cartridge - available from General Metal Works (Model PS-1). See Figure 1.

7.2 Sampling Head to contain glass cartridge with PUF plug - available from General Metal Works. See Figure 2.

7.3 Calibration orifice - available from General Metal Works.

7.4 Manometer - to use with calibration orifice.

7.5 Soxhlet extraction system - including Soxhlet extractors (500 and 250 mL), heating mantels, variable voltage transformers, and cooling water source - for extraction of PUF cartridges before and after sampling. Also for extraction of filter samples.

7.6 Vacuum oven connected to water aspirator - for drying extracted PUF cartridges.

7.7 Gas chromatograph with electron capture detector - (consult U. S. EPA Method 608 for specifications).

7.8 Forceps - to handle quartz fiber filter samples.

7.9 Die - to cut PUF plugs.

7.10 Various items for extract preparation, cleanup, and analysis - consult U. S. EPA Method 608 for detailed listing.

7.11 Chromatography column - 2 mm I.D. x 15 cm long - for alumina cleanup.

8. Reagent and Materials

8.1 Polyurethane foam - 3 inch thick sheet stock, polyether type used in furniture upholstering. Density 0.022 g/cm^3.

8.2 Polyester gloves - for handling PUF cartridges and filters

8.3 Filters, quartz fiber - Pallflex 2500 QAST , or equivalent.

8.4 Wool felt filter - 4.9 mg/cm^2 and 0.6 mm thick. To fit sample head for collection efficiency studies. Pre-extracted with 5% diethyl ether in hexane.

8.5 Hexane - Pesticide or distilled in glass grade.

8.6 Diethyl ether - preserved with 2% ethanol - distilled in glass grade, or equivalent.

8.7 Acetone - Pesticide or distilled in glass grade,

8.8 Glass container for PUF cartridges.

8.9 Glass petri dish - for shipment of filters to and from the laboratory.

8.10 Ice chest - to store samples at ~0°C after collection.

8.11 Various materials needed for extract preparation, cleanup, and analysis - consult U. S. EPA Method 608 for details (Appendix A of this compendium).

8.12 Alumina - activity grade IV. 100/200 mesh

9. Assembly and Calibration of Sampling Apparatus

9.1 Description of Sampling Apparatus

9.1.1 The entire sampling system is diagrammed in Figure 1. This sampler was developed by Syracuse University

Research Corporation (SURC) under a U. S. EPA contract (6) and further modified by Southwest Research Institute and the U. S. EPA. A unit specifically designed for this method is now commercially available (Model PS-1 - General Metal Works, Inc., Village of Cleves, Ohio). The method writeup assumes the use of the commercial device, although the earlier modified device is also considered acceptable.

9.1.2 The sampling module (Figure 2) consists of a glass sampling cartridge and an air-tight metal cartridge holder. The PUF plug is retained in the glass sampling cartridge.

9.2 *Calibration of Sampling System*

9.2.1 The airflow through the sampling system is monitored by a venturi/Manehelic assembly, as shown in Figure 1. A multipoint calibration of the venturi/magnehelic assembly must be conducted every six months using an audit calibration orifice, as described in the U. S. EPA High Volume Sampling Method (8). A single point calibration must be performed before and after each sample collection, using the procedure described below.

9.2.2 Prior to calibration a "dummy" PUF cartridge and filter are placed in the sampling head and the sampling motor is activated. The flow control valve is fully opened and the voltage variator is adjusted so that a sample flow rate corresponding to ~110% of the desired flow rate is indicated on the magnehelic (based on the previously obtained multipoint calibration curve). The motor is allowed to warmup for ~10 minutes and then the flow control valve is adjusted to achieve the desired flow rate. The ambient temperature and barometric pressure should

be recorded on an appropriate data sheet (e.g. Figure 3).

9.2.3 The calibration orifice is then placed on the sampling head and a manometer is attached to the tap on the calibration orifice. The sampler is momentarily turned off to set the zero level of the manometer. The sampler is then switched on and the manometer reading is recorded, once a stable reading is achieved. The sampler is then shut off.

9.2.4 The calibration curve for the orifice is used to calculate sample flow from the data obtained in 9.2.3, and the calibration curve for the venturi/ magnehelic assembly is used to calculate sample flow from the data obtained in 9.2.2. The calibration data should be recorded on an appropriate data sheet (e.g. Figure 3). If the two values do not agree within 10% the sampler should be inspected for damage, flow blockage, etc. If no obvious problems are found the sampler should be recalibrated (multipoint) according to the U. S. EPA High Volume Sampling procedure (8).

9.2.5 A multipoint calibration of the calibration orifice, against a primary standard, should be obtained annually.

10. Preparation of Sampling (PUF) Cartridges

10.1 The PUF adsorbent is a polyether-type polyurethane foam (density No. 3014 or 0.0225 g/cm^3). This type of foam is used for furniture upholstery. It is white and yellows on exposure to light.

10.2 The PUF inserts are 6.0 cm diameter cylindrical plugs cut from 3 inch sheet stock and should fit with slight compression in the glass cartridge, supported by the wire

screen. See Figure 2. During cutting the die is rotated at high speed (e.g. in a drill press) and continuously lubricated with water.

10.3 For initial cleanup the PUF plug is placed in a Soxhlet extractor and extracted with acetone for 14-24 hours at approximately 4 cycles per hour. When cartridges are reused, 5% diethyl ether in n-hexane can be used as the cleanup solvent.

10.4 The extracted PUF is placed in a vacuum oven connected to a water aspirator and dried at room temperature for approximately 2-4 hours (until no solvent odor is detected).

10.5 The PUF is placed into the glass sampling cartridge using polyester gloves. The module is wrapped with hexane rinsed aluminum foil, placed in a labeled container and tightly sealed.

10.6 Other adsorbents may be suitable for this method as indicated in the various references (1-3). If such materials are employed the user must define appropriate preparation procedures based on the information contained in these references.

10.7 At least one assembled cartridge from each batch must be analyzed, as a laboratory blank, using the procedures described in Section 12, before the batch is considered acceptable for field use. A blank level of <10 ng/plug for single compounds is considered to be acceptable. For multiple component mixtures (e.g. Arochlors) the blank level should be <100 ng/plug.

11. Sampling

11.1 After the sampling system has been assembled and calibrated as described in Section 9 it can be used to collect air samples as described below.

11.2 The samples should be located in an unobstructed area, at least two meters from any obstacle to air flow. The exhaust hose should be stretched out in the downwind

direction to prevent recycling of air.

11.3 A clean sampling cartridge and quartz fiber filter are removed from sealed transport containers and placed in the sampling head using forceps and gloved hands. The head is tightly sealed into the sampling system. The aluminum foil wrapping is placed back in the sealed container for later use.

11.4 The zero reading of the Magnehelic is checked. Ambient temperature, barometric pressure, elapsed time meter setting, sampler serial number, filter number and PUF cartridge number are recorded. A suitable data sheet is shown in Figure 4.

11.5 The voltage variator and flow control valve are placed at the settings used in 9.2.3 and the power switch is turned on. The elapsed time meter is activated and the start time recorded. The flow (Magnehelic setting) is adjusted, if necessary using the flow control valve.

11.6 The Magnehelic reading is recorded every six hours during the sampling period. The calibration curve (Section 9.2.7) is used to calculate the flow rate. Ambient temperature and barometric pressure are recorded at the beginning and end of the sampling period.

11.7 At the end of the desired sampling period the power is turned off and the filter and PUF cartridges are wrapped with the original aluminum foil and placed in sealed, labeled containers for transport back to the laboratory.

11.8 The Magnehelic calibration is checked using the calibration orifice as described in Section 9.2.4. If the calibration deviates by more than 10% from the initial reading the flow data for that sample must be marked as suspect and the sampler should be inspected and/or removed from service.

11.9 At least one field blank will be returned to the laboratory with each group of samples. A field blank is treated exactly as a sample except that no air is drawn through the cartridge.

11.10 Samples are stored at ~20°C in an ice chest until receipt at the analytical laboratory, at which time they are stored refrigerated at 4°C.

12. Sample Preparation and Analysis

12.1 Sample Preparation

12.1.1 All samples should be extracted within 1 week after collection.

12.1.2 PUF cartridges are removed from the sealed container using gloved hands, the aluminum foil wrapping is removed, and the cartridges are placed into a 500-mL Soxhlet extraction. The cartridges are extracted for 14-24 hours at ~4 cycles/hour with 5% diethyl ether in hexane. Extracted cartridges can be dried and reused following the handling procedures in Section TO. The quartz filter can be placed in the extractor with the PUF cartridges. However, if separate analysis is desired then one can proceed with 12.1.3.

12.1.3 If separate analysis is desired, quartz filters are placed in a 250-mL Soxhlet extractor and extracted for 14-24 hours with 5% diethyl ether in hexane.

12.1.4 The extracts are concentrated to 10 mL final volume using 500-mL Kuderna-Danish concentrators as described in EPA Method 608 (5), using a hot water bath. The concentrated extracts are stored refrigerated in sealed 4-dram vials having teflon-lined screw-caps until analyzed or subjected to cleanup.

12.2 Sample Cleanup

12.2.1 If only organochlorine pesticides and PCBs are sought, an alumina cleanup procedure reported in the literature is appropriate (1). Prior to cleanup the sample

extract is carefully reduced to 1 mL using a gentle steam of clean nitrogen.

12.2.2 A glass chromatographic column (2 mm ID x 15 cm long) is packed with alumina, activity grade IV and rinsed with ~20 mL of n-hexane. The concentrated sample extract (from 12.2.1) is placed on the column and eluted with 10 mL of n-hexane at a rate of 0.5 mL/minute. The eluate volume is adjusted to exactly 10 mL and analyzed as described in 12.3.

12.2.3 If other pesticides are sought, alternate cleanup procedures (e.g. Florisil) may be required. Method 608 (5) identifies appropriate cleanup procedures.

12.3 Sample Analysis

12.3.1 Sample analysis is performed using GC/ECD as described in EPA Method 608 (5). The user must consult this method for detailed analytical procedures.

12.3.2 GC retention times and conditions are identified in Table 1 for the compounds of interest.

13. GC Calibration

Appropriate calibration procedures are identified in EPA Method 608 (5).

14. Calculations

14.1 The total sample volume (V_m) is calculated from the periodic flow readings (Magnehelic) taken in Section 11.6 using the following equation.

$$V_m = \frac{Q_1 + Q_2 \ldots Q_N}{N} X \frac{T}{1000}$$

where

V_m = Total sample volume (m^3).

Q_1, $Q_2 \ldots Q_N$ = Flow rates determined at the beginning, end, and intermediate points during sampling (L/minute).

N = Number of data points averaged.

T = Elapsed sampling time (minutes).

14.2 The volume of air sampled can be converted to standard conditions (760 mm Hg pressure and 25°C) using the following equation:

$$V_s = V_m \times \frac{P_A}{760} \times \frac{298}{273+t_A}$$

where

V_s = Total sample volume at 25°C and 760 mm Hg pressure (m^3)

V_m = Total sample flow under ambient conditions (m^3)

P_A = Ambient pressure (mm Hg)

t_A = Ambient temperature (°C)

14.3 The concentration of compound in the sample is calculated using the following equation:

$$C_A = \frac{A \times V_E}{V_1 \times V_s}$$

where

C_A = Concentration of analyte in the sample, ug/m^3

A = Calculated amount of material injected onto the chromatograph based on calibration curve for injected standards (nanograms)

V_1 = Volume of extract injected (uL).

V_E = Final volume of extract (mL).
V_s = Total volume of air samples corrected to standard conditions (m^3).

14. Performance Criteria and Quality Assurance

This section summarizes the quality assurance (QA) measures and provides guidance concerning performance criteria which should be achieved within each laboratory.

14.1 Standard Operating Procedures (SOPs)

14.1.1 Users should generate SOPs describing the following activities as accomplished in their laboratory: 1) assembly, calibration and operation of the sampling system, 2) preparation, purification, storage and handling of sampling cartridges, 3) assembly, calibration and operation of the GC/ECD system, and 4) all aspects of data recording and processing.

14.1.2 SOPs should provide specific stepwise instructions and should be readily available to, and understood by, the laboratory personnel conducting the work.

14.2 Process, Field, and Solvent Blanks

14.2.1 One PUF cartridge and filter from each batch of approximately twenty should be analyzed, without shipment to the field, for the compounds of interest to serve as a process blank.

14.2.2 During each sampling episode at least one PUF cartridge and filter should be shipped to the field and returned, without drawing air through the sampler, to serve as a field blank.

14.2.3 During the analysis of each batch of samples at least one solvent process blank (all steps conducted but no PUF cartridge or filter included) should be

carried through the procedure and analyzed.

14.2.4 Blank levels should not exceed ~10 ng/sample for single components or ~100 ng/sample for multiple component mixtures (e.g. PCBs).

14.3 Collection Efficiency and Spike Recovery

14.3.1 Before using the method for sample analysis each laboratory must determine their collection efficiency for the components of interest.

14.3.2 The glass fiber filter in the sampler is replaced with a hexane-extracted wool felt filter (weight 14.9 mg/cm^2, 0.6 mm thick). The filter is spiked with microgram amounts of the compounds of interest by dropwise addition of hexane solutions of the compounds. The solvent is allowed to evaporate and filter is placed into the sampling system for immediate use.

14.3.3 The sampling system, including a clean PUF cartridge, is activated and set at the desired sampling flow rate. The sample flow is monitored for 24 hours.

14.3.4 The filter and PUF cartridge are then removed and analyzed as described in Section 12.

14.3.5 A second sample, unspiked is collected over the same time period to account for any background levels of components in the ambient air matrix.

14.3.6 A third PUF cartridge is spiked with the same amounts of the compounds used in 14.3.2 and extracted to determine analytical recovery.

14.3.7 In general analytical recoveries and collection efficiencies of 75% are considered to be acceptable method performance.

14.3.8 Replicate (at least triplicate) determinations of collection efficiency should be made. Relative standard deviations for these replicate determinations of ± 15% or less is considered acceptable performance.

14.3.9 Blind spiked samples should be included with sample sets periodically, as a check on analytical performance.

14.4 Method Precision and Accuracy

Typical method recovery data are shown in Table 1. Recoveries for the various chlorobiphenyls illustrate the fact that all components of an Arochlor mixture will not be retained to the same extent. Recoveries for tetrachlorobiphenyls and above are generally greater than 85% but di- and trichloro homologs may not be recovered quantitatively.

REFERENCES

1. Lewis, R. G., Brown, A. R., and Jackson, M. D., "Evaluation of Polyurethane Foam for Sampling of Pesticides, Polychlorinated Biphenyls, and Polychlorinated Naphthalenes in Ambient Air", Anal. Chem. 49, 1668-1672, 1977.

2. Lewis, R. G. and Jackson, M. D., "Modification and Evaluation of a High-Volume Air Sampler for Pesticides and Semivolatile Industrial Organic Chemicals", Anal. Chem. 54, 592-594, 1982.

3. Lewis, R. G., Jackson, M. D., and MacLeod, K. E., "Protocol for Assessment of Human Exposure to Airborne Pesticides", EPA-600/2-80-180, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1980.

4. Riggin, R. M., "Technical Assistance Document for Sampling and Analysis of Toxic Organic Compounds in Ambient Air", EPA-600/4-83-027., U. S. Environmental Protection Agency, Research Triangle Park, NC, 1983.

5. Longbottom, J. E. and Lichtenberg, J. J., "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", EPA-600/4-82-057, U. S. Environmental Protection Agency, Cincinnati, OH, 1982.

6. Bjorkland, J., Compton, B., and Zweig, G., "Development of Methods for Collection and Analysis of Airborne Pesticides." Report for Contract No. CPA 70-15, National Air Pollution Control Association, Durham, NC, 1970.

7. Annual Book of ASTM Standards, Part 11.03, "Atmospheric Analysis", American Society for Testing and Materials, Philadelphia, PA, 1983.

8. Reference Method for the Determination of Suspended Particulates in the Atmosphere (High Volume Method). Federal Register, Sept. 14, 1972 or 40CFR50 Appendix B.

TABLE 1. SELECTED COMPONENTS DETERMINED USING HI-VOL/PUF SAMPLING PROCEDURE

Compound	GC Retention Time, Minutes[a]	24-Hour Sampling Efficiency[b]	
		Air Concentration ng/m^3	% Recovery
Aldrin	2.4	0.3-3.0	28
4,4'-DDE	5.1	0.6-6.0	89
4,4'-DDT	9.4	1.8-18	83
Chlordane	(c)	15-150	73
Chlorobiphenyls			
4,4' Di-	--	2.0-20	62
2,4,5 Tri-	---	0.2-2.0	36
2,4',5 Tri-	--	0.2-2.0	86
2,2',5,5' Tetra-	--	0.2-2.0	94
2,2',4,5,5' Penta-	--	0.2-2.0	92
2,2',4,4',5,5' Hexa	--	0.2-2.0	86

(a) Data from U.S. EPA Method 608. Conditions are as follows:

Stationary Phase - 1.5% SP2250/1.95% SP-2401 on Supelcoport (100/120 mesh) packed in 1.8 mm long x 4 mm ID glass column.

Carrier - 5/95 methane/Argon at 60 mL/Minute

Column Temperature - 160°C except for PCBs which are determined at 200°C.

(b) From Reference 2.

(c) Multiple component formulation. See U.S. EPA Method 608.

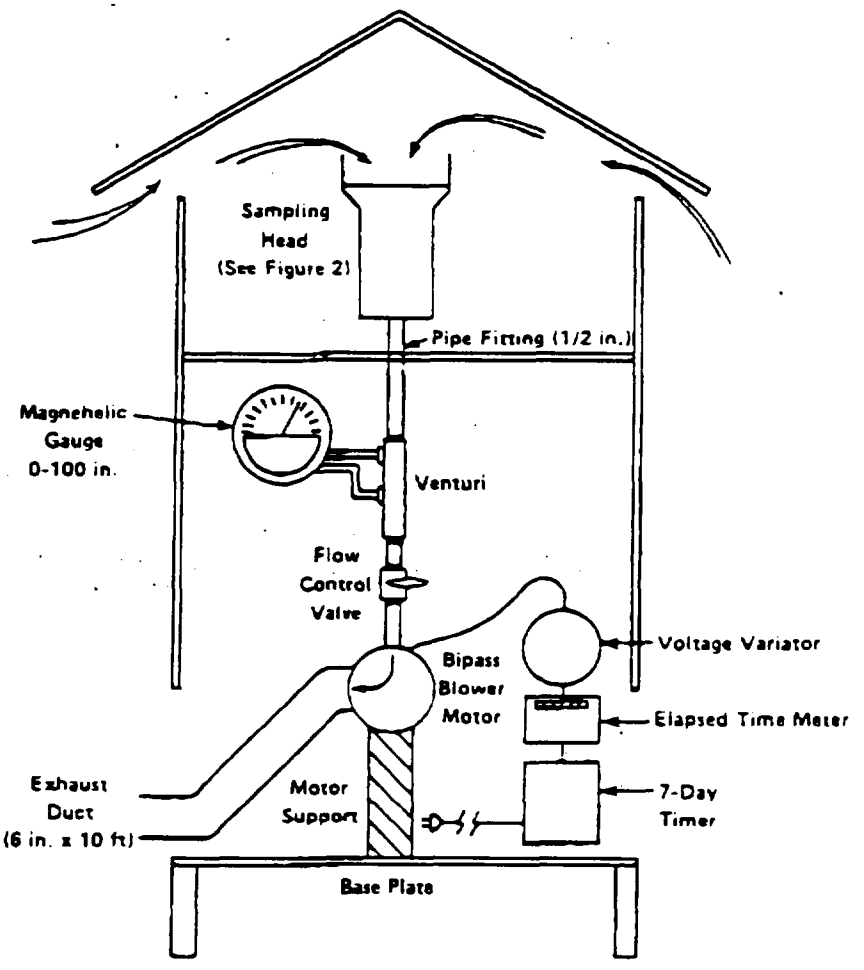


FIGURE 1. HIGH VOLUME AIR SAMPLER. AVAILABLE FROM GENERAL METAL WORKS (MODEL PS-1)

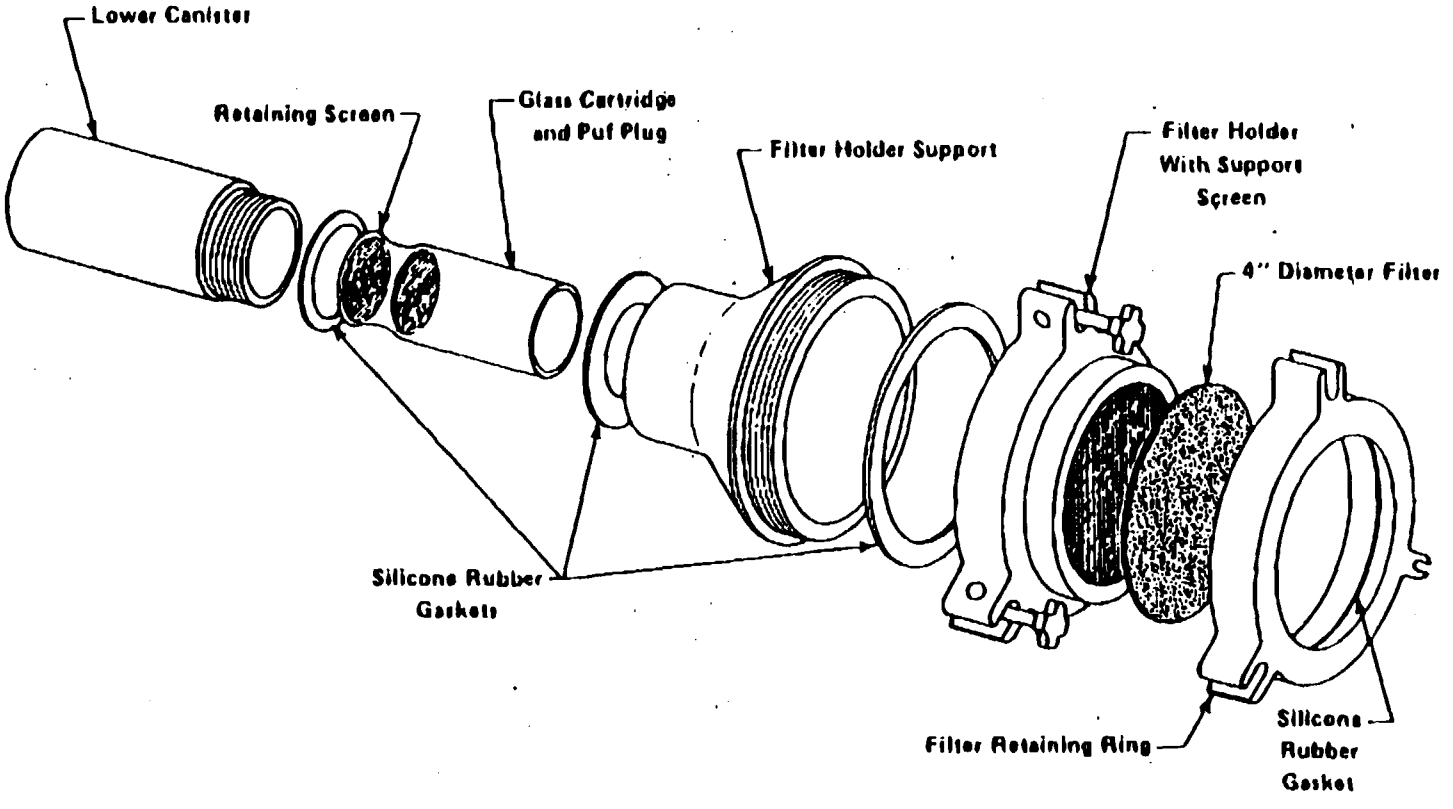


FIGURE 2. SAMPLING HEAD

Performed by _____ Calibration Orifice S/N _____ Ambient Temperature _____ °C

Date/Time _____ Manometer S/N _____ Bar.Press. _____ mm Hg

Sampler S/N	Variac Setting V	Timer OK? Yes/No	Calibration Orifice Data		Sampler Venturi Data		% Difference Between Calibration and Sample Venturi Flow Rates	Comments
			Manometer, in. H_2O	Flow Rate, scm /min[a]	Magnehelic, in. H_2O	Flow Rate scm/min [b]		

(a) From Calibration Tables for Calibration Orifice or Venturi Tube

(b) From Calibration Tables for Venturi Tube in each Hi-Vol unit. Date check by _____ Date _____

FIGURE 3. TYPICAL CALIBRATION SHEET FOR HIGH VOLUME SAMPLER

Site _____ Date _____ Performed by _____

Sampler S/N	Sampling Location ID	Mfrm Fltr I.D.	PUF Cart No	Vortex Sensing	Clock Time			Sampler Timer			Venturi Readings Time/Magnehelic in. H_2O				Ambient Temperature °C		Barometric Pressure mm Hg		Comments
					Start, hr CDT	Stop, hr CDT	Min Elapsed	Start, min	Stop, min	Min Elapsed	1	2	3	4	Start	Stop	Start	Stop	

[a] Record any evidence of tampering with sampler and/or photoelectronics in sampler operation, PUF cartridge condition or handling, etc.

Data Checked By _____ Date _____

T04-20

FIGURE 4. TYPICAL SAMPLING DATA FORM FOR HIGH VOLUME PESTICIDE/PCB SAMPLER

Revision 1.0
September, 1986

METHOD TO9

METHOD FOR THE DETERMINATION OF POLYCHLORINATED DIBENZO-p-DIOXINS (PCDDs) IN AMBIENT AIR USING HIGH-RESOLUTION GAS CHROMATOGRAPHY/HIGH-RESOLUTION MASS SPECTROMETRY (HRGC/HRMS)

1. Scope

1.1 This document describes a method for the determination of polychlorinated dibenzo-p-dioxins (PCDDs) in ambient air. In particular, the following PCDDs have been evaluated in the laboratory utilizing this method:

- 1,2,3,4-tetrachlorodibenzo-p-dioxin (1,2,3,4-TCDD)
- 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin (1,2,3,4,7,8-H_xCDD)
- Octachlorodibenzo-p-dioxin (OCDD)
- 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)

The method consists of sampling ambient air via an inlet filter followed by a cartridge (filled with polyurethane foam) and analysis of the sample using high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS). Original laboratory studies have indicated that the use of polyurethane foam (PUF) or silica gel in the sampler will give equal efficiencies for retaining PCDD/PCDF isomers; i.e., the median retention efficiencies for the PCDD isomers ranged from 67 to 124 percent with PUF and from 47 to 133 percent with silica gel. Silica gel, however, produced lower levels of background interferences than PUF. The detection limits were, therefore, approximately four times lower for tetrachlorinated isomers and ten times lower for hexachlorinated isomers when using silica gel as the adsorbent. The difference in detection limit was approximately a factor of two for the octachlorinated isomers. However, due to variable recovery and extensive cleanup required with silica gel, the method has been written using PUF as the adsorbent.

1.2 With careful attention to reagent purity and other factors, the method can detect PCDDs in filtered air at levels below 15 pg/m^3.

1.3 Average recoveries ranged from 68 percent to 140 percent in laboratory evaluations of the method sampling ultrapure filtered air. Percentage recoveries and sensitivities obtainable for ambient air samples have not been determined.

2. Applicable Documents

2.1 ASTM Standards

2.1.1 Method D1356 - Definitions of Terms Relating to Atmospheric Sampling and Analysis.

2.1.2 Method E260 - Recommended Practice for General Gas Chromatography Procedures.

2.1.3 Method E355 - Practice for Gas Chromatography Terms and Relationships.

2.2 EPA Documents

2.2.1 Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II - "Ambient Air Specific Methods," Section 2.2 - "Reference Method for the Determination of Suspended Particulates in the Atmosphere," Revision 1, July, 1979, EPA-600/4-77-027A.

2.2.2. Protocol for the Analysis of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin by High Resolution Gas Chromatography-High Resolution Mass Spectrometry, U.S. Environmental Protection Agency, January, 1986, EPA-600/4-86-004.

2.2.3 Evaluation of an EPA High Volume Air Sampler for Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans, undated report by Battelle under Contract 68-02-4127, Project Officers Robert G. Lewis and Nancy K. Wilson, U.S. Environmental Protection Agency, EMSL, Research Triangle Park, North Carolina.

2.2.4 Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, U.S. Environmental Protection Agency, April, 1984, 600/4-84-041.

2.2.5 Technical Assistance Document for Sampling and Analysis of Toxic Organic Compounds in Ambient Air, U.S. Environmental Protection Agency, June, 1983, EPA-600/4-83-027.

2.3 Other Documents

2.3.1 General Metal Works Operating Procedures for Model PS-1 Sampler, General Metal Works, Inc., Village of Cleves, Ohio.

2.3.2 Chicago Air Quality: PCB Air Monitoring Plan, Phase 2, Illinois Environmental Protection Agency, Division of Air Pollution Control, April, 1986, IEPA/APC/86-011.

3. Summary of Method

3.1 Filters and adsorbent cartridges (containing PUF) are cleaned in solvents and vacuum-dried. The filters and adsorbent cartridges are stored in screw-capped jars wrapped in aluminum foil (or otherwise protected from light) before careful installation on a modified high volume sampler.

3.2 Approximately 325 m^3 of ambient air is drawn through a cartridge on a calibrated General Metal Works Model PS-1 Sampler, or equivalent (breakthrough has not been shown to be a problem with sampling volumes of 325 m^3).

3.3 The amount of air sampled through the adsorbent cartridge is recorded, and the cartridge is placed in an appropriately labeled container and shipped along with blank adsorbent cartridges to the analytical laboratory for analysis.

3.4 The filters and PUF adsorbent cartridge are extracted together with benzene. The extract is concentrated, diluted with hexane, and cleaned up using column chromatography.

3.5 The High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS) system is verified to be operating properly and is calibrated with five concentration calibration solutions, each analyzed in triplicate.

3.6 A preliminary analysis of a sample of the extract is performed to check the system performance and to ensure that the samples are within the calibration range of the instrument. If necessary, recalibrate the instrument, adjust the amount of the sample injected, adjust the calibration solution concentration, and adjust the data processing system to reflect observed retention times, etc.

3.7 The samples and the blanks are analyzed by HRGC/HRMS and the results are used (along with the amount of air sampled) to calculate the concentrations of polychlorinated dioxins in ambient air.

4. Significance

4.1 Polychlorinated dibenzo-p-dioxins (PCDDs) are extremely toxic. They are carcinogenic and are of major environmental concern. Certain isomers, for example, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), have LD50 values in the parts-per-trillion range for some animal species. Major sources of these compounds have been commercial processes involving polychlorinated phenols and polychlorinated biphenyls (PCBs). Recently, however, combustion sources have been shown to emit polychlorinated dibenzo-p-dioxin (PCDD), including the open-flame combustion of wood containing chlorophenol wood preservatives, and emissions from burning transformers and/or capacitors that contain PCBs and chlorobenzenes.

4.2 Several documents have been published which describe sampling and analytical approaches for PCDDs, as outlined in Section 2.2. The attractive features of these methods have been combined in this procedure. This method has not been validated in its final form, and, therefore, one must use caution when employing it for specific applications.

4.3 The relatively low level of PCDDs in the environment requires the use of high volume sampling techniques to acquire sufficient samples for analysis. However, the volatility of PCDDs prevents efficient collection on filter media. Consequently, this method utilizes both a filter and a PUF backup cartridge which provides for efficient collection of most PCDDs.

5. Definitions

Definitions used in this document and in any user-prepared standard operating procedures (SOPs) should be consistent with ASTM Methods D1356 and E355 (Sections 2.1.1 and 2.1.3). All abbreviations and symbols within this document are defined the first time they are used.

6. Interferences

6.1 Chemicals that elute from the gas chromatographic (GC) column within ±10 scans of the standards or compounds of interest and which produce, within the retention time windows, ions with any mass-to-charge (m/e) ratios close enough to those of the ion fragments used to detect or quantify the analyte compounds are potential interferences. Most frequently encountered potential interferences are other sample components that are extracted along with PCDDs, e.g., polychlorinated biphenyls (PCBs), methoxybiphenyls, chlorinated hydroxydiphenylethers, chlorinated naphthalenes, DDE, DDT, etc. The actual incidence of interference by these compounds also depends upon relative concentrations, mass spectrometric resolution, and chromatographic conditions. Because very low levels of PCDDs must be measured, the elimination of interferences is essential. High-purity reagents and solvents must be used and all equipment must be scrupulously cleaned. Laboratory reagent blanks must be analyzed to demonstrate absence of contamination that would interfere with the measurements. Column chromatographic procedures are used to remove some coextracted sample components; these procedures must be performed carefully to minimize loss of analyte compounds during attempts to increase their concentration relative to other sample components.

6.2 In addition to chemical interferences, inaccurate measurements could occur if PCDDs are retained on particulate matter, the filter, or PUF adsorbent cartridge, or are chemically changed during sampling and storage in ways that are not accurately measured by adding isotopically labeled spikes to the samples.

6.3 The system cannot separately quantify gaseous PCDDs and particulate PCDDs because the material may be lost from the filter by volatilization after collection and may be transferred to the absorbent cartridge. Gaseous PCDDs may also be adsorbed on particulate matter on the filter.

7. Apparatus

7.1 General Metal Works (GMW) Model PS-1 Sampler.

7.2 At least two Model PS-1 sample cartridges and filters per PS-1 Sampler.

7.3 Calibrated GMW Model 40 calibrator.

7.4 High-Resolution Gas Chromatograph/High-Resolution Mass Spectrometer/Data System (HRGC/HRMS/DS)

7.4.1 The GC must be equipped for temperature programming, and all required accessories must be available, including syringes, gases, and a capillary column. The GC injection port must be designed for capillary columns. The use of splitless injection techniques is recommended. On-column injection techniques can be used but they may severely reduce column lifetime for nonchemically bonded columns. In this protocol, a 2-uL injection volume is used consistently. With some GC injection ports, however, 1-uL injections may produce some improvement in precision and chromatographic separation. A 1-uL injection volume may be used if adequate sensitivity and precision can be achieved.

[NOTE: If 1 uL is used as the injection volume, the injection volumes for all extracts, blanks, calibration solutions and performance check samples must be 1 uL.]

7.4.2 Gas Chromatograph-Mass Spectrometer Interface. The gas chromatograph is usually coupled directly to the mass spectrometer source. The interface may include a diverter valve for shunting the column effluent and isolating the mass spectrometer source. All components of the interface should be glass or glass-lined stainless

steel. The interface components should be compatible with 300°C temperatures. Cold spots and/or active surfaces (adsorption sites) in the GC/MS interface can cause peak tailing and peak broadening. It is recommended that the GC column be fitted directly into the MS source. Graphic ferrules should be avoided in the GC injection area since they may adsorb TCDD. Vespel® or equivalent ferrules are recommended.

7.4.3 Mass Spectrometer. The static resolution of the instrument must be maintained at a minimum of 10,000 (10 percent valley). The mass spectrometer must be operated in a selected ion monitoring (SIM) mode with a total cycle time (including voltage reset time) of one second or less (Section 12.3.4.1). At a minimum, ions that occur at the following masses must be monitored:

2,3,7,8-TCDD	1,2,3,4,7,8-H_xCDD	OCDD
258.9300	326.8521	394.7742
319.8965	389.8156	457.7377
321.8936	391.8127	459.7347
331.9368		
333.93338		

7.4.4 Data System. A dedicated computer data system is employed to control the rapid multiple ion monitoring process and to acquire the data. Quantification data (peak areas or peak heights) and SIM traces (displays of intensities of each m/z being monitored as a function of time) must be acquired during the analyses. Quantifications may be reported based upon computer-generated peak areas or upon measured peak heights (chart recording). The detector zero setting must allow peak-to-peak measurement of the noise on the baseline.

7.4.5 GC Column. A fused silica column (30 m x 0.25 mm I.D.) coated with DB-5, 0.25 u film thickness (J & S Scientific, Inc., Crystal Lake, IL) is utilized to separate each of the several tetra- through octa-PCDDs, as a group, from all of the other groups. This column also resolves 2,3,7,8-TCDD from all 21 other TCDD isomers; therefore, 2,3,7,8-TCDD can be determined quantitatively if proper calibration procedures are followed as per Sections 12.3 through 12.6. Other columns may be used for determination of PCDDs, but separation of the wrong PCDD isomers must be demonstrated and documented. Minimum acceptance criteria must be determined as per Section 12.1. At the beginning of each 12-hour period (after mass resolution has been demonstrated) during which sample extracts or concentration calibration solutions will be analyzed, column operating conditions must be attained for the required separation on the column to be used for samples.

7.5 All required syringes, gases, and other pertinent supplies to operate the HRGC/HRMS system.

7.6 Airtight, labeled screw-capped containers to hold the sample cartridges (perferably glass with Teflon seals or other noncontaminating seals).

7.7 Data sheets for each sample for recording the location and sample time, duration of sample, starting time, and volume of air sampled.

7.8 Balance capable of weighing accurately to $\pm$0.001 g.

7.9 Pipettes, micropipets, syringes, burets, etc., to make calibration and spiking solutions, dilute samples if necessary, etc., including syringes for accurately measuring volumes such as 25 uL and 100 uL of isotopically labeled dioxin solutions.

7.10 Soxhlet extractors capable of extracting GMW PS-1 PUF adsorbent cartridges (2.3" x 5" length), 500-mL flask, and condenser.

7.11 Vacuum drying oven system capable of maintaining the PUF cartridges being evacuated at 240 torr (flushed with nitrogen) overnight.

7.12 Ice chest - to store samples at 0°C after collection.

7.13 Glove box for working with extremely toxic standards and reagents with explosion-proof hood for venting fumes from solvents reagents, etc.

7.14 Adsorption columns for column chromatography - 1 cm x 10 cm and 1 cm x 30 cm, with stands.

7.15 Concentrator tubes and a nitrogen evaporation apparatus with variable flow rate.

7.16 Laboratory refrigerator with chambers operating at 0°C and 4°C.

7.17 Kuderna-Danish apparatus - 500 mL evaporating flask, 10 mL graduated concentrator tubes with ground-glass stoppers, and 3-ball macro Snyder Column (Kontes K-570001-0500, K-50300-0121, and K-569001-219, or equivalent).

7.18 Two-ball micro Snyder Column, Kuderna-Danish (Kontes 569001-0219, or equivalent).

7.19 Stainless steel spatulas and spoons.

7.20 Minivials - 1 mL, borosilicate glass, with conical reservoir and screw caps lined with Teflon-faced silicone disks, and a vial holder.

7.21 Chromatographic columns for Carbopak cleanup - disposable 5-mL graduated glass pipets, 6 to 7 mm ID.

7.22 Desiccator.

7.23 Polyester gloves for handling PUF cartridges and filter.

7.24 Die - to cut PUF plugs.

7.25 Water bath equipped with concentric ring cover and capable of being temperature-controlled within $\pm$2°C.

7.26 Erlenmeyer flask, 50 mL.

7.27 Glass vial, 40 mL.

7.28 Cover glass petri dishes for shipping filters.

7.29 Fritted glass extraction thimbles.

7.30 Pyrex glass tube furnace system for activating silica gel at 180°C under purified nitrogen gas purge for an hour, with capability of raising temperature gradually.

[NOTE: Reuse of glassware should be minimized to avoid the risk of cross-contamination. All glassware that is used, especially glassware that is reused, must be scrupulously cleaned as soon as possible after use. Rinse glassware with the last solvent used in it and then with high-purity acetone and hexane. Wash with hot water containing detergent. Rinse with copious amount of tap water and several portions of distilled water. Drain, dry, and heat in a muffle furnace at 400°C for 2 to 4 hours. Volumetric glassware must not be heated in a muffle furnace; rather, it should be rinsed with high-purity acetone and hexane. After the glassware is dry and cool, rinse it with hexane, and store it inverted or capped with solvent-rinsed aluminum foil in a clean environment.]

8. Reagents and Materials

8.1 Ultrapure glass wool, silanized, extracted with methylene chloride and hexane, and dried.

8.2 Ultrapure acid-washed quartz fiber filters for PS-1 Sampler (Pallfex 2500 glass, or equivalent).

8.3 Benzene (Burdick and Jackson, glass-distilled, or equivalent).

8.4 Hexane (Burdick and Jackson, glass-distilled, or equivalent).

8.5 Alumina, acidic - extracted in a Soxhlet apparatus with methylene chloride for 6 hours (minimum of 3 cycles per hour) and activated by heating in a foil-covered glass container for 24 hours at 190°C.

8.6 Silica gel - high-purity grade, type 60, 70-230 mesh; extracted in a Soxhlet apparatus with methylene chloride for 6 hours (minimum of 3 cycles per hour) and activated by heating in a foil-covered glass container for 24 hours at 130°C.

8.7 Silica gel impregnated with 40 percent (by weight) sulfuric acid - prepared by adding two parts (by weight) concentrated sulfuric acid to three parts (by weight) silica gel (extracted and activated) and mixiing with a glass rod until free of lumps; stored in a screw-capped glass bottle.

8.8 Graphitized carbon black (Carbopak C or equivalent), surface of approximately 12 m^2/g, 80/100 mesh - prepared by thoroughly mixing 3.6 grams Carbopak C and 16.4 grams Celite 545® in a 40-mL vial and activating at 130°C for six hours; stored in a desiccator.

8.9 Sulfuric Acid, ultrapure, ACS grade, specific gravity 1.84.

8.10 Sodium Hydroxide, ultrapure, ACS grade.

8.11 Native and isotopically labeled PCDD/PCDF isomers for calibration and spiking standards, from Cambridge Isotopes, Cambridge, MA.

8.12 n-decane (Aldrich Gold Label grade [D90-1], or equivalent).

8.13 Toluene (high purity, glass-distilled).

8.14 Acetone (high purity, glass-distilled).

8.15 Filters, quartz fiber - Pallflex 2500 QAST, or equivalent.

8.16 Ultrapure nitrogen gas (Scott chromatographic grade, or equivalent).

8.17 Methanol (chromatographic grade).

8.18 Methylene chloride (chromatographic grade, glass-distilled).

8.19 Dichloromethane/hexane (3:97, v/v), chromatographic grade.

8.20 Hexane/dichloromethane (1:1, v/v), chromatogtraphic grade.

8.21 Perfluorokerosene (PFK), chromatographic grade.

8.22 Celite 545®, reagent grade, or equivalent.

8.23 Membrane filters or filter paper with pore sizes less than 25 um, hexane-rinsed.

8.24 Granular anhydrous sodium sulfate, reagent grade.

8.25 Potassium carbonate-anhydrous, granular, reagent grade.

8.26 Cyclohexane, glass-distilled.

8.27 Tridecane, glass-distilled.

8.28 2,2,3-trimethylpentane, glass-distilled.

8.29 Isooctane, glass-distilled.

8.30 Sodium sulfate, ultrapure, ACS grade.

8.31 Polyurethane foam - 3 inches thick sheet stock, polyether type used in furniture upholstering, density 0.022 g/cm^3.

8.32 Concentration calibration solutions (Table 1) - four tridecane solutions containing $^{13}C_{12}$-1,2,3,4-TCDD (recovery standard) and unlabeled 2,3,7,8-TCDD at varying concentrations, and $^{13}C_{12}$-2,3,7,8-TCDD (internal standard, CAS RN 80494-19-5). These solutions must be obtained from the Quality Assurance Division, U.S. EPA, Environmental Monitoring Systems Laboratory (EMSL-LV), Las Vegas, Nevada, and must be used to calibrate the instrument. However, secondary standards may be obtained from commercial sources, and solutions may be prepared in the analytical laboratory. Traceability of standards must be verified against EPA-supplied standard solutions by procedures documented in laboratory SOPs. Care must be taken to use the correct standard. Serious overloading of instruments may occur if concentration calibration solutions intended for low-resolution MS are injected into the high-resolution MS.

8.33 Column performance check mixture dissolved in 1 mL of tridecane from Quality Assurance Division (EMSL-LV). Each ampule of this solution will contain approximately 10 ng of the following components (A) eluting near 2,3,7,8-TCDD and of the first (F) and last-eluting (L) TCDDs, when using the recommended columns at a concentration of 10 pg/uL of each of these isomers:

- o unlabeled 2,3,7,8-TCDD
- o $^{13}C_{12}$-2,3,7,8-TCDD
- o 1,2,3,4-TCDD (A)
- o 1,4,7,8-TCDD (A)
- o 1,2,3,7-TCDD (A)
- o 1,2,3,8-TCDD (A)
- o 1,3,6,8-TCDD (F)
- o 1,2,8,9-TCDD (L)

If these solutions are unavailable from EPA, they should be prepared by the analytical laboratory or a chemical supplier and analyzed in a manner traceable to the EPA performance check mixture designed for 2,3,7,8-TCDD monitoring. Similar mixtures of isotopically labeled compounds should be prepared to check performance for monitoring other specific forms of TCDD that are of interest.

8.34 Sample fortification solution - isooctane solution containing the internal standard at a nominal concentration of 10 pg/uL.

8.35 Recovery standard spiking solution - tridecane solution containing the isotopically labeled standard ($^{13}C_{12}$-2,3,7,8-TCDD and other PCDDs of interest) at a concentration of 10.0 pg/uL.

8.36 Field blank fortification solutions - isooctane solutions containing the following:

- Solution A: 10.0 pg/uL of unlabeled 2,3,7,8-TCDD
- Solution B: 10.0 pg/uL of unlabeled 1,2,3,4-TCDD

[NOTE: These reagents and the detailed analytical procedures described herein are designed for monitoring TCDD isomer concentrations of 6.0 pg/m^3 to 37 pg/m^3 each. If ambient concentrations should exceed these levels, concentrations of calibrations and spiking solutions will need to be modified, along with the detailed sample preparation procedures. The reagents and procedures described herein are based on Appendix B of the Protocol for the Analysis of 2,3,7,8-TCDD (Section 2.2.2) combined with the evaluation of the high volume air sampler for PCDD.

9. Preparation of PUF Sampling Cartridge

9.1 The PUF adsorbent is a polyether-type polyurethane foam (density No. 3014 or 0.0225 g/cm^3) used for furniture upholstery.

9.2 The PUF inserts are 6.0-cm diameter cylindrical plugs cut from 3-inch sheet stock and should fit, with slight compression, in the glass cartridge, supported by the wire screen (Figure 1). During cutting, the die is rotated at high speed (e.g., in a drill press) and continuously lubricated with water.

9.3 For initial cleanup, the PUF plug is placed in a Soxhlet apparatus and extracted with acetone for 14-24 hours at approximately 4 cycles per hour. When cartridges are reused, 5% diethyl ether in n-hexane can be used as the cleanup solvent.

9.4 The extracted PUF is placed in a vacuum oven connected to a water aspirator and dried at room temperature for approximately 2-4 hours (until no solvent odor is detected).

9.5 The PUF is placed into the glass sampling cartridge using polyester gloves. The module is wrapped with hexane-rinsed aluminum foil, placed in a labeled container, and tightly sealed.

9.6 At least one assembled cartridge from each batch must be analyzed, as a laboratory blank, using the procedures described in Section 11, before the batch is considered acceptable for field use. A blank level of <10 ng/plug for single compounds is considered to be acceptable.

10. Sample Collection

10.1 Description of Sampling Apparatus

10.1.1 The entire sampling system is diagrammed in Figure 2. A unit specifically designed for this method is commercially available (Model PS-1 - General Metal Works, Inc., Village of Cleves, Ohio).

10.1.2 The sampling module (Figure 1) consists of a glass sampling cartridge and an air-tight metal cartridge holder. The PUF is retained in the glass sampling cartridge.

10.2 Calibration of Sampling System

10.2.1 The airflow through the sampling system is monitored by a Venturi/Magnehelic assembly, as shown in Figure 2. Assembly must be audited every six months using an audit calibration orifice, as described in the U.S. EPA High Volume Sampling Method, 40 CFR 50, Appendix B. A single-point calibration must be performed before and after each sample collection, using the procedure described in Section 10.2.2.

10.2.2 Prior to calibration, a "dummy" PUF cartridge and filter are placed in the sampling head and the sampling motor is activated. The flow control valve is fully opened and the voltage variator is adjusted so that a sample flow rate corresponding to 110% of the desired flow rate is indicated on the Magnehelic (based on the previously obtained multipoint calibration curve). The motor is allowed to warm up for 10 minutes and then the flow control

valve is adjusted to achieve the desired flow rate. The ambient temperature and barometric pressure should be recorded on an appropriate data sheet.

10.2.3 The calibration orifice is placed on the sampling head and a manometer is attached to the tap on the calibration orifice. The sampler is momentarily turned off to set the zero level of the manometer. The sampler is then switched on and the manometer reading is recorded after a stable reading is achieved. The sampler is then shut off.

10.2.4 The calibration curve for the orifice is used to calculate sample flow from the data obtained in Section 10.2.3, and the calibration curve for the Venturi/ Magnehelic assembly is used to calculate sample flow from the data obtained in Section 10.2.2. The calibration data should be recorded on an appropriate data sheet. If the two values do not agree within 10%, the sampler should be inspected for damage, flow blockage, etc. If no obvious problems are found, the sampler should be recalibrated (multipoint) according to the U.S. EPA High Volume Sampling Method (Section 10.2.1).

10.2.5 A multipoint calibration of the calibration orifice. against a primary standard, should be obtained annually.

10.3 Sample Collection

10.3.1 After the sampling system has been assembled and calibrated as described in Sections 10.1 and 10.2, it can be used to collect air samples, as described in Section 10.3.2.

10.3.2. The samples should be located in an unobstructed area, at least two meters from any obstacle to air flow. The exhaust hose should be stretched out in the downwind direction to prevent recycling of air.

10.3.3 A clean PUF sampling cartridge and quartz filter are removed from sealed transport containers and placed in the sampling head using forceps and gloved hands. The head is tightly sealed into the sampling system. The aluminum foil wrapping is placed back in the sealed container for later use.

10.3.4 The zero reading of the Magnehelic is checked. Ambient temperature, barometric pressure, elapsed time meter setting, sampler serial number, filter number, and PUF cartridge number are recorded on a suitable data sheet, as illustrated in Figure 3.

10.3.5 The voltage variator and flow control valve are placed at the settings used in Section 10.2.3, and the power switch is turned on. The elapsed time meter is activated and the start time is recorded. The flow (Magnehelic setting) is adjusted, if necessary, using the flow control valve.

10.3.6 The Magnehelic reading is recorded every six hours during the sampling period. The calibration curve (Section 10.2.4) is used to calculate the flow rate. Ambient temperature and barometric pressure are recorded at the beginning and end of the sampling period.

10.3.7 At the end of the desired sampling period, the power is turned off and the filter and PUF cartridges are wrapped with the original aluminum foil and placed in sealed, labeled containers for transport back to the laboratory.

10.3.8 The Magnehelic calibration is checked using the calibration orifice, as described in Section 10.2.4. If calibration deviates by more than 10% from the initial reading, the flow data for that sample must be marked as suspect and the sampler should be inspected and/or removed from service.

10.3.9 At least one field filter/PUF blank will be returned to the laboratory with each group of samples. A field blank is treated exactly as a sample except that no air is drawn through the filter/PUF cartridge assembly.

10.3.10 Samples are stored at 20°C in an ice chest until receipt at the analytical laboratory, after which they are refrigerated at 4°C.

11. Sample Extraction

11.1 Immediately before use, charge the Soxhlet apparatus with 200 to 250 mL of benzene and reflux for 2 hours. Let the apparatus cool, disassemble it, transfer the benzene to a clean glass container, and retain it as a blank for later analysis, if required. After sampling, spike the cartridges and filters with an internal standard (Table 1). After spiking, place the PUF cartridge and filter together in the Soxhlet apparatus (the use of an extraction thimble is optional). (The filter and PUF cartridge are analyzed together in order to reach detection limits, avoid questionable interpretation of the data, and minimize cost.) Add 200 to 250 mL of benzene to the apparatus and relux for 18 hours at a rate of at least 3 cycles per hour.

11.2 Transfer the extract to a Kuderna-Danish (K-D) apparatus, concentrate it to 2 to 3 mL, and let it cool. Rinse the column and flask with 5 mL of benzene, collecting the rinsate in the concentrator tube to 2 to 3 mL. Repeat the rinsing and concentration steps twice more. Remove the concentrator tube from the K-D apparatus and carefully reduce the extract volume to approximately 1 mL with a stream of nitrogen using a flow rate and distance above the solution such that a gentle rippling of the solution surface is observed.

11.3 Perform the following column chromatographic procedures for sample extraction cleanup. These procedures have been demonstrated to be effective for a mixture consisting of:

- 1,2,3,4-TCDD
- 1,2,3,4,7,8-H_xCDD
- OCDD
- 2,3,7,8-TCDD

11.3.1 Prepare an acidic silica gel column as follows (Figure 4): Pack a 1 cm x 10 cm chromatographic column with a glass wool plug, a 1-cm layer of Na_2SO_4/K_2CO_3 (1:1), 1.0 g of silica gel (Section 8.6), and 4.0 g of 40-percent (w/w) sulfuric acid-impregnated silica gel (Section 8.7). Pack a second chromatographic column (1 cm x 30 cm) with a glass wool plug and 6.0 g of acidic alumina (Section 8.5), and top it with a 1-cm layer of sodium sulfate (Section 8.30). Add hexane to the columns until they are free of channels and air bubbles.

11.3.2 Quantitatively transfer the benzene extract (1 mL) from the concentrator tub to the top of the silica gel column. Rinse the concentrator tube with 0.5-mL portions of hexane. Transfer the rinses to the top of the silica gel column.

11.3.3 Elute the extract from the silica gel column with 90 of mL hexane directly into a Kudena-Danish concentrator tube. Concentrate the eluate to 0.5 mL, using nitrogen blowdown, as necessary.

11.3.4 Transfer the concentrate (0.5 mL) to the top of the alumina column. Rinse the K-D assembly with two 0.5-mL portions of hexane, and transfer the rinses to the top of the alumina column. Elute the alumina column with 18 mL hexane until the hexane level is just below the top of the sodium sulfate. Discard the eluate. Do not let the columns reach dryness (i.e., maintain a solvent "head").

11.3.5 Place 30 mL of 20% (v/v) methylene chloride in hexane on top of the alumina column and elute the TCDDs from the column. Collect this fraction in a 50-mL Erlenmeyer flask.

11.3.6 Certain extracts, even after cleanup by column chromatography, contain interferences that preclude determination of TCDD at low parts-per-trillion levels. Therefore, a cleanup step is included using activated carbon which selectively retains planar molecules such as TCDDs. The TCDDs are then removed from the carbon by elution with toluene. Proceed as follows: Prepare an 18% Carbopak C/Celite 545® mixture by thoroughly mixing 3.6 grams Carbopak C (80/100 mesh) and 16.4 grams Celite 545® in a 40-mL vial. Activate the mixture at 130°C for 6 hours, and store it in a desiccator. Cut off a clean 5-mL disposable glass pipet at the 4-mL mark. Insert a plug of glass wool (Section 8.1) and push it to the 2-mL mark. Add 340 mg of the activated Carbopak/Celite mixture followed by another glass wool plug. Using two glass rods, push both glass wool plugs simultaneously toward the Carbopak/Celite plug to a length of 2.0 to 2.5 cm. Pre-elute the column with 2 mL of toluene followed by 1 mL of 75:20:5 methylene chloride/methanol/ benzene, 1 mL of 1:1 cyclohexane in methylene choride, and 2 mL of hexane. The flow rate should be less than 0.5 mL per minute. While the column is still wet with hexane, add the entire elute (30 mL) from the alumina column (Section 11.3.5) to the top of the column. Rinse the Erlenmeyer flask that contained the extract twice with 1 mL of hexane and add the rinsates to the top of the column. Elute the column sequentially with two 1-mL aliquots of hexane, 1 mL of 1:1 cyclohexane in methylene chloride, and 1 mL of 75:20:5 methylene

chloride/mentanol/benzene. Turn the column upside down and elute the TCDD fraction into a concentrator tube with 6 mL of toluene. Warm the tube to approximately 60°C and reduce the toluene volume to approximately 1 mL using a stream of nitrogen. Carefully transfer the residue into a 1-mL minivial and, again at elevated temperature, reduce the volume to about 100 uL using a stream of nitrogen. Rinse the concentrator tube with 3 washings using 200 uL of 1% toluene in CH_2Cl_2 each time. Add 50 uL of tridecane and store the sample in a refrigerator until GC/MS analysis is performed.

12. HRGC/HRMS System Performance Criteria

The laboratory must document that the system performance criteria specified in Sections 12.1, 12.2, and 12.3 have been met before analysis of samples.

12.1 GC Column Performance

12.1.1 Inject 2 uL of the column performance check solution (Section 8.33) and acquire selected ion monitoring (SIM) data for m/z 258.930, 319.897, 321.894, and 333.933 within a total cycle time of $\leq$1 second.

12.1.2 The chromatographic peak separation between 2,3,7,8-TCDD and the peaks representing any other TCDD isomers must be resolved with a valley of $\leq$25%, where

$$\text{Valley Percent} = (x/y)(100)$$

x = measured distance from extroplated baseline to minimum of valley; and

y = the peak height of 2,3,7,8-TCDD.

[Note: It is the responsibility of the laboratory to verify the conditions suitable for the appropriate resolution of 2,3,7,8-TCDD from all other TCDD isomers. The column performance check solution also contains the TCDD isomers eluting first and last under the analytical conditions specified in this protocol, thus defining

the retention time window for total TCDD determination. The peaks representing 2,3,7,8-TCDD, and the first and last eluting TCDD isomers must be labeled and identified.]

12.2 Mass Spectometer Performance

12.2.1 The mass spectrometer must be operated in the electron (impact) ionization mode. Static mass resolution of at least 10,000 (10% valley) must be demonstrated before any analysis of a set of samples is performed (Section 12.2.2). Static resolution checks must be performed at the beginning and at the end of each 12-hour period of operation. However, it is recommended that a visual check (e.g., not documented) of the static resolution be made using the peak matching unit before and after each analysis.

12.2.2 Chromatography time for TCDD may exceed the long-term mass stability of the mass spectrometer; therefore, mass drift correction is mandatory. A reference compound (high boiling perfluorokerosene [PFK] is recommended) is introduced into the mass spectrometer. An acceptable lock mass ion at any mass between m/z 250 and m/z 334 (m/z 318.979 from PFK is recommended) must be used to monitor and correct mass drifts.

[NOTE: Excessive PFK may cause background noise problems and contamination of the source, resulting in an increase in "downtime" for source cleaning. Using a PFK molecular leak, tune the instrument to meet the minimum required mass resolution of 10,000 (10% valley) at m/z 254.986 (or any other mass reasonably close to m/z 259). Calibrate the voltage sweep at least across the mass range m/z 259 to m/z 344 and verify that m/z 330.979 from PFK (or any other mass close to m/z 334) is measured within ±5 ppm (i.e., 1.7 mmu). Document the mass resolution by recording the peak profile of the PFK reference peak m/z 318.979 (or any other reference peak at a mass close to m/z 320/322). The format of the peak profile representation must allow manual determination of the resolution;

i.e., the horizontal axis must be a calibrated mass scale (mmu or ppm per division). The result of the peak width measurement (performed at 5 percent of the maximum) must appear on the hard copy and cannot exceed 31.9 mmu or 100 ppm.]

12.3 Initial Calibration

Intitial calibration is required before any samples are analyzed for 2,3,7,8-TCDD. Initial calibration is also required if any routine calibration does not meet the required criteria listed in Section 12.6.

12.3.1 All concentration calibration solutions listed in Table 1 must be utilized for the initial calibration.

12.3.2 Tune the instrument with PFK as described in Section 12.2.2.

12.3.3 Inject 2 uL of the column performance check solution (Section 8.33) and acquire SIM mass spectral data for m/z 258.930, 319.897, 321.894, 331.937, and 333.934 within a total cycle time of $\leq$1 second. The laboratory must not perform any further analysis until it has been demonstrated and documented that the criterion listed in Section 12.1.2 has been met.

12.3.4 Using the same GC (Section 12.1) and MS (Section 12.2) conditions that produced acceptable results with the column performance check solution, analyze a 2-uL aliquot of each of the 5 concentration calibration solutions in triplicate with the gas chromatographic operating parameters shown in Table 2.

12.3.4.1 Total cycle time for data acquisition must be $\leq$1 second. Total cycle time includes the sum of all the dwell times and voltage reset times.

12.3.4.2 Acquire SIM data for the following selected characteristic ions:

m/z	Compound
258.930	TCDD - COCl
319.897	unlabeled TCDD
321.894	unlabeled TCDD
331.937	$^{13}C_{12}$-2,3,7,8-TCDD, $^{13}C_{12}$-1,2,3,4-TCDD
333.934	$^{13}C_{12}$-2,3,7,8-TCDD, $^{13}C_{12}$-1,2,3,4-TCDD

12.3.4.3 The ratio of intergrated ion current for m/z 319.897 to m/z 321.894 for 2,3,7,8-TCDD must be between 0.67 and 0.87 (±13%).

12.3.4.4 The ratio of integrated ion current for m/z 331.937 to m/z 333.934 for $^{13}C_{12}$-2,3,7,8-TCDD and $^{13}C_{12}$-1,2,3,4-TCDD must be between 0.67 and 0.87.

12.3.4.5 Calculate the relative response factor for unlabeled 2,3,7,8-TCDD [RRF(I)] relative to $^{13}C_{12}$-2,3,7,8-TCDD and for labeled $^{13}C_{12}$-2,3,7,8-TCDD [RRF(II)] relative to $^{13}C_{12}$-1,2,3,4-TCDD as follows:

$$RRF(I) = \frac{A_x \cdot Q_{IS}}{Q_x \cdot A_{IS}}$$

$$RRF(II) = \frac{A_{IS} \cdot Q_{RS}}{Q_{IS} \cdot A_{RS}}$$

where:

A_x = sum of the integrated abundances of m/z 319.897 and m/z 321.894 for unlabeled 2,3,7,8,-TCDD.

A_{IS} = sum of the integrated abundances of m/z 331.937 and m/z 333.934 for $^{13}C_{12}$-2,3,7,8-TCDD.

A_{RS} = sum of the integrated abundances for m/z 331.937 and m/z 333.934 for $^{13}C_{12}$-1,2,3,4-TCDD.

Q_{IS} = quantity (pg) of $^{13}C_{12}$-2,3,7,8-TCDD injected.

Q_{RS} = quantity (pg) of $^{13}C_{12}$-1,2,3,4-TCDD injected.

Q_x = quantity (pg) of unlabeled 2,3,7,8-TCDD injected.

12.4 Criteria for Acceptable Calibration

The criteria listed below for acceptable calibration must be met before analysis of any sample is performed.

12.4.1 The percent relative standard deviation (RSD) for the response factors from each of the triplicate analyses for both unlabeled and $^{13}C_{12}$-2,3,7,8-TCDD must be less than $\pm$20%.

12.4.2 The variation of the five mean RRFs for unlabeled 2,3,7,8-TCDD obtained from the triplicate analyses must be less than $\pm$20% RSD.

12.4.4 SIM traces for $^{13}C_{12}$-2,3,7,8-TCDD must present a signal-to-noise ratio $\geq$10 for 333.934.

12.4.5 Isotopic ratios (Sections 12.3.4.3 and 12.3.4.4) must be within the allowed range.

[NOTE: If the criteria for acceptable calibration listed in Sections 12.4.1 and 12.4.2 have been met, the RRF can be considered independent of the analyte quantity for the calibration concentration range. The mean RRF from five triplicate determinations for unlabeled 2,3,7,8-TCDD and for $^{13}C_{12}$2,3,7,8-TCDD will be used for all calculations until routine calibration criteria (Section 12.6) are no longer met. At such time, new mean RRFs will be calculated from a new set of five triplicate determinations.]

12.5 Routine Calibration

Routine calibration must be performed at the beginning of each 12-hour period after successful mass resolution and GC column performance check runs.

12.5.1 Inject 2 uL of the concentration calibration solution (Section 8.32) that contains 5.0 pg/uL of unlabeled 2,3,7,8-TCDD, 10.0 pg/uL of $^{13}C_{12}$-2,3,7,8-TCDD, and 5.0 pg/uL $^{13}C_{12}$-1,2,3,4-TCDD. Using the same GC/MS/DS conditions as in Sections 12.1, 12.2, and 12.3, determine and document acceptable calibration as provided in Section 12.6.

12.6 Criteria for Acceptable Routine Calibration

The following criteria must be met before further analysis is performed. If these criteria are not met, corrective action must be taken and the instrument must be recalibrated.

12.6.1 The measured RRF for unlabeled 2,3,7,8-TCDD must be within ±20 percent of the mean values established (Section 12.3.4.5) by triplicate analyses of concentration calibration solutions.

12.6.2 The measured RRF for $^{13}C_{12}$-2,3,7,8-TCDD must be within ±20 percent of the mean value established by triplicate analyses of concentration calibration solutions (Section 12.3.4.5).

12.6.3 Isotopic ratios (Sections 12.3.4.3 and 12.3.4.4) must be within the allowed range.

12.6.4 If one of the above criteria is not satisfied, a second attempt can be made before repeating the entire initialization process (Section 12.3).

[NOTE: An initial calibration must be carried out whenever any HRCC solution is replaced.]

13. Analytical Procedures

13.1 Remove the sample extract or blank from storage, allow it to warm to ambient laboratory temperature, and add 5 uL of recovery standard solution. With a stream of dry, purified nitrogen, reduce the extract/blank volume to 20 uL.

13.2 Inject a 2-uL aliquot of the extract into the GC, which should be operating under the conditions previously used (Section 12.1) to produce acceptable results with the performance check solution.

13.3 Acquire SIM data using the same acquisition time and MS operating conditions previously used (Section 12.3.4) to determine the relative response factors for the following selected characteristic ions:

m/z	Compound
258.930	TCDD - COCl (weak at detection limit level)
319.897	unlabeled TCDD
321.894	unlabeled TCDD
331.937	$^{13}C_{12}$-2,3,7,8-TCDD, $^{13}C_{12}$-1,2,3,4-TCDD,
333.934	$^{13}C_{12}$-2,3,7,8-TCDD, $^{13}C_{12}$-1,2,3,4-TCDD,

13.4 Identification Criteria

13.4.1 The retention time (RT) (at maximum peak height) of the sample component m/z 319.897 must be within -1 to +3 seconds of the retention time of the peak for the isotopically labeled internal standard at m/z 331.937 to attain a positive identification of 2,3,7,8-TCDD. Retention times of other tentatively identified TCDDs must fall within the RT window established by analyzing the column performance check solution (Section 12.1). Retention times are required for all chromatograms.

13.4.2 The ion current responses for m/z 258.930, 319.897 and 321.894 must reach their maxima simultaneously ($\pm$1 scan), and all ion current intensities must be $\geq$2.5 times noise level for positive identification of a TCDD.

13.4.3 The integrated ion current at m/z 319.897 must be between 67 and 87 percent of the ion current response at m/z 321.894.

13.4.4 The integrated ion current at m/z 331.937 must be between 67 and 87 percent of the ion current response at m/z 333.934.

13.4.5 The integrated ion currents for m/z 331.937 and 333.934 must reach their maxima within ±1 scan.

13.4.6 The recovery of the internal standard $^{13}C_{12}$-2,3,7,8-TCDD must be between 40 and 120 percent.

14. Calculations

14.1 Calculate the concentration of 2,3,7,8-TCDD (or any other TCDD isomer) using the formula:

$$C_X = \frac{A_X \cdot Q_{IS}}{A_{IS} \cdot V \cdot \overline{\overline{RRF}}(I)}$$

where:

C_X = quantity (pg) of unlabeled 2,3,7,8-TCDD (or any other unlabeled TCDD isomer) present.

A_X = sum of the integrated ion abundances determined for m/z 319.897 and 321.894.

A_{IS} = sum of the integrated ion abundances determined for m/z 331.937 and 333.934 of $^{13}C_{12}$-2,3,7,8-TCDD (IS = internal standard).

Q_{IS} = quantity (pg) of $^{13}C_{12}$-2,3,7,8-TCDD added to the sample before extraction (Q_{IS} = 500 pg).

V = volume (m^3) of air sampled.

$\overline{\overline{RRF}}(I)$ = Calculated mean relative response factor for unlabeled 2,3,7,8-TCDD relative to $^{13}C_{12}$-2,3,7,8-TCDD. This value represents the grand mean of the RRF(I)s obtained in Section 12.3.4.5.

14.2 Calculate the recovery of the internal standard $^{13}C_{12}$-2,3,7,8-TCDD, measured in the sample extract, using the formula:

$$\text{Internal standard, percent recovery} = \frac{A_{IS} \cdot Q_{RS}}{A_{RS} \cdot \overline{\overline{\overline{RRF}}}(II) \cdot Q_{IS}} \times 100$$

where:

A_{IS} and Q_{IS} = same definitions as above (Section 14.1)

A_{RS} = sum of the integrated ion abundances determined for m/z 331.937 and 333.934 of $^{13}C_{12}$-1,2,3,4-TCDD (RS = recovery standard).

Q_{RS} = quantity (pg) of $^{13}C_{12}$-1,2,3,4-TCDD added to the sample residue before HRGC-HRMS analysis (Q_{RS} = 500 pg).

RRF(II) = Calculated mean relative response factor for labeled $^{13}C_{12}$-2,3,7,8-TCDD. This value represents the grand mean of the RRF(II)s calculated in Section 12.3.4.5.

14.3 Total TCDD Concentration

14.3.1 All positively identified isomers of TCDD must be within the RT window and meet all identification criteria listed in Sections 13.4.2, 13.4.3, and 13.4.4. Use the expression in Section 14.1 to calculate the concentrations of the other TCDD isomers, with C_X becoming the concentration of any unlabeled TCDD isomer.

14.4 Estimated Detection Limit

14.4.1 For samples in which no unlabeled 2,3,7,8-TCDD was detected, calculate the estimated minimum detectable concentration. The background area is determined by integrating the ion abundances for m/z 319.897 and 321.894 in the appropriate region and relating that height area to an estimated concentration that would produce that product area. Use the formula:

$$CE = \frac{(2.5) \cdot (A_x) \cdot (Q_{IS})}{(A_{IS}) \cdot \overline{\overline{\overline{RRF}}}(I) \cdot (W)}$$

where:

C_E = estimated concentration of unlabeled 2,3,7,8-TCDD required to produce A_x.

A_x = sum of integrated ion abundance for m/z 319.897 and 321.894 in the same group of $\geq$25 scans used to measure A_{IS}.

A_{IS} = sum of integrated ion abundance for the appropriate ion characteristic of the internal standard, m/z 331.937 and m/z 333.934.

Q_{IS}, $\overline{RRF}(I)$, and V retain the definitions previously stated in Section 14.1. Alternatively, if peak height measurements are used for quantification, measure the estimated detection limit by the peak height of the noise in the TCDD RT window.

14.5 The relative percent difference (RPD) is calculated as follows:

$$RPD = \frac{|S_1 - S_2|}{(\text{Mean Concentration})} = \frac{|S_1 - S_2|}{(S_1 + S_2)/2} \times 100$$

S_1 and S_2 represent sample and duplicate sample results.

14.6 The total sample volume (V_m) is calculated from the periodic flow readings (Magnehelic) taken in Section 10.3.6 using the following equation:

$$V_m = \frac{Q_1 + Q_2 \cdots Q_N}{N} \times \frac{T}{1000}$$

where:

V_m = total sample volume (m^3).

$Q_1\ Q_2 \cdots Q_N$ = flow rates determined at the beginning, end, and intermediate points during sampling (L/minute).

N = number of data points averaged.

T = elapsed sampling time (minutes).

14.7 The concentration of compound in the sample is calculated using the following equation:

$$V_S = V_m \times \frac{P_A}{760} \times \frac{298}{273 + t_A}$$

where:

V_S = total sample volume (m^3) at 25°C and 760 mm Hg pressure.
V_m = total sample flow (m^3) under ambient conditions.
P_A = ambient pressure (mm Hg).
t_A = ambient temperature (°C).

14.8 The concentration of compound in the sample is calculated using the following equation:

$$C_A = \frac{A \times V_E}{V_i \times V_S}$$

where:

C_A = concentration (ug/m^3) of analyte in the sample.
A = calculated amount of material determined by HRGC/HRMS.
V_i = volume (uL) of extract injected.
V_E = final volume (mL) of extract.
V_S = total volume (m^3) of air samples corrected to standard conditions.

15. Performance Criteria and Quality Assurance

This section summarizes required quality assurance (QA) measures and provides guidance concerning performance criteria that should be achieved within each laboratory.

15.1 Standard Operating Procedures (SOPs)

15.1.1 Users should generate SOPs describing the following activities in their laboratory: 1) assembly, calibration and operation of the sampling system with make and model of equipment used; 2) preparation, purification, storage, and handling of sampling cartridges and filters; 3) assembly, calibration and operation of the HRGC/HRMS system with make and model of equipment used; 4) all aspects of data recording and processing, including lists of computer hardware and software used.

15.1.2 SOPs should provide specific stepwise instructions and should be readily available to and understood by the laboratory personnel conducting the work.

15.2 Process, Field, and Solvent Blanks

15.2.1 One PUF cartridge and filter from each batch of approximately 20 should be analyzed, without shipment to the field, for the compounds of interest to serve as process blank.

15.2.2 During each sampling episode, at least one PUF cartridge and filter should be shipped to the field and returned, without drawing air through the sampler, to serve as a field blank.

15.2.3 During the analysis of each batch of samples, at least one solvent process blank (all steps conducted but no PUF cartridge or filter included) should be carried through the procedure and analyzed.

TABLE 1
COMPOSITION OF CONCENTRATION CALIBRATION SOLUTIONS

	Recovery Standards	Analyte	Internal Standard
	$^{13}C_{12}$-1,2,3,4-TCDD	2,3,7,8-TCDD	$^{13}C_{12}$-2,3,7,8-TCDD
HRCC1	2.5 pg/uL	2.5 pg/uL	10.0 pg/uL
HRCC2	5.0 pg/uL	5.0 pg/uL	10.0 pg/uL
HRCC3	10.0 pg/uL	10.0 pg/uL	10.0 pg/uL
HRCC4	20.0 pg/uL	20.0 pg/uL	10.0 pg/uL
HRCC5	40.0 pg/uL	40.0 pg/uL	10.0 pg/uL

Sample Fortification Solution

5.0 pg/uL of $^{13}C_{12}$-2,3,7,8-TCDD

Recovery Standard Spiking Solution

100 pg/uL $^{13}C_{12}$-1,2,3,4-TCDD

Field Blank Fortification Solutions

A) 4.0 pg/uL of unlabeled 2,3,7,8-TCDD

B) 5.0 pg/uL of unlabeled 1,2,3,4-TCDD

TABLE 2

RECOMMENDED GC OPERATING CONDITIONS

Column coating	SP-2330 (SP 2331)	CP-SIL 88
Film thickness	0.20 um	0.22 um
Column dimensions	60 m x 0.24 mm	50 m x 0.22 mm
Helium linear velocity	28-29 cm/sec at 240°C	28-29 cm/sec at 240°C
Initial temperature	200°C	190°C
Initial time	4 min	3 min
Temperature program	200°C to 250°C at 4°C/min	190°C to 240°C at 5°C/min

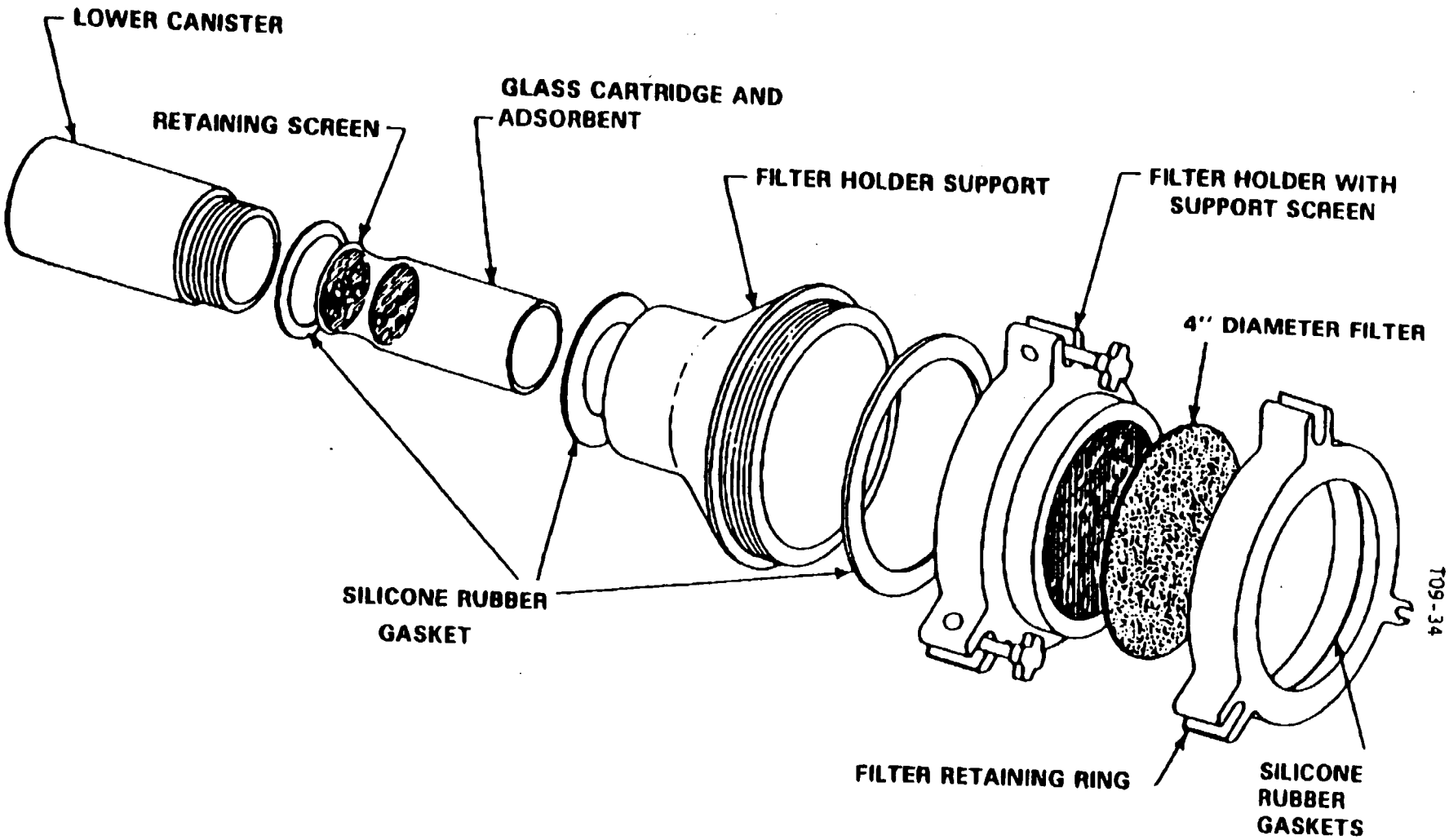


FIGURE 1. SAMPLING HEAD

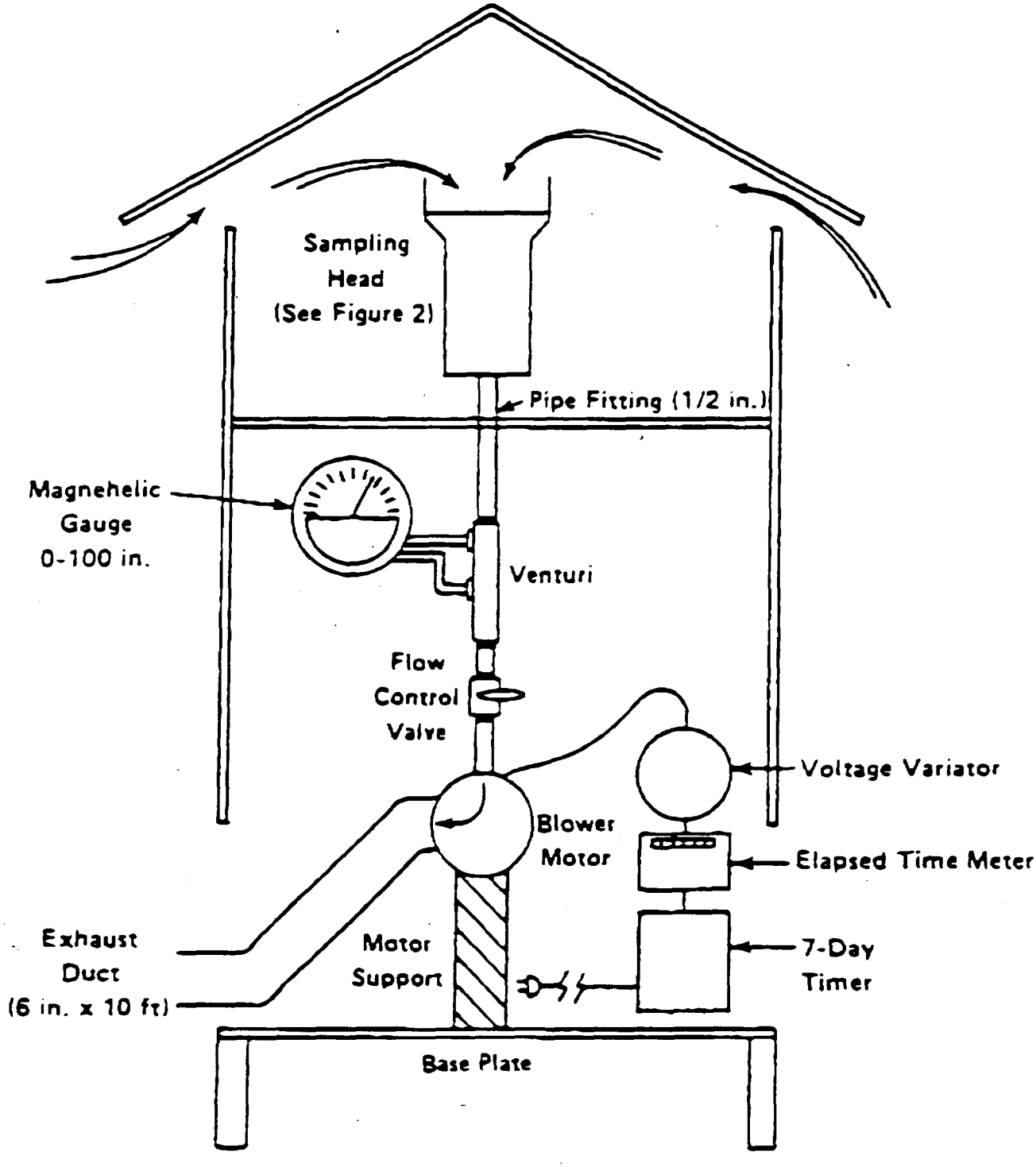


FIGURE 2. HIGH VOLUME AIR SAMPLER
GENERAL METAL WORKS (MODEL PS-1)

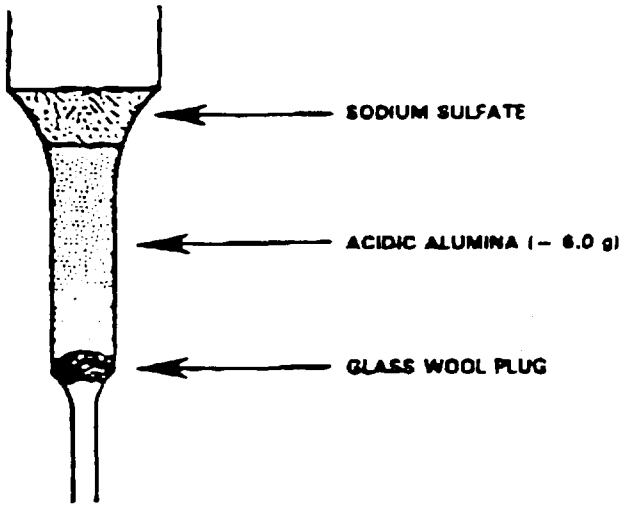
Performed by_____ Calibration Orifice S/N_____ Ambient Temperature_____°C

Date/Time_____ Manometer S/N _____ Bar. Press._____mm Hg

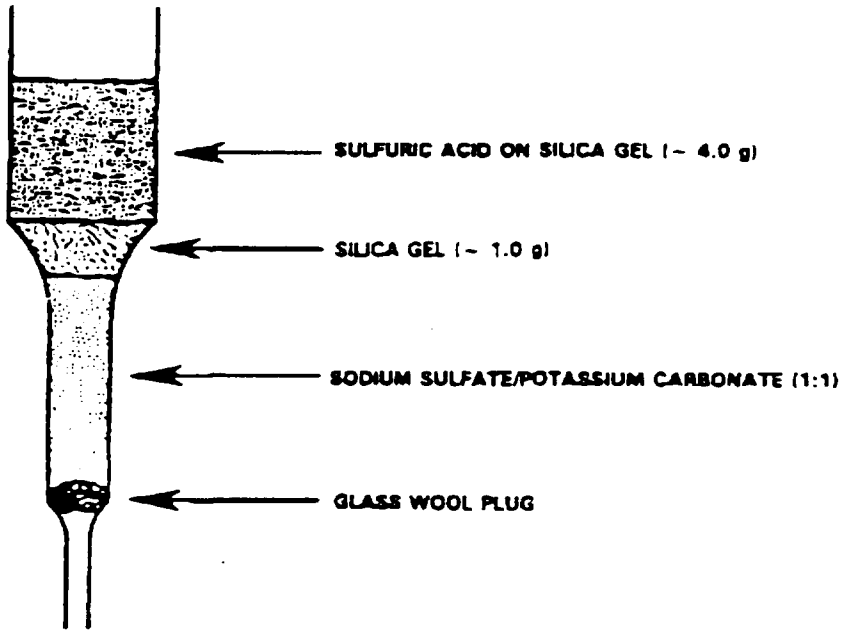
Sampler S/N	Variac Setting V	Timer OK? Yes/No	Calibration Orifice Data		Sampler Venturi Data		% Difference Between Calibration and Sample Venturi Flow Rates	Comments
			Manometer, in. H_2O	Flow Rate scm/min[a]	Magnehelic, in. H_2O	Flow Rate scm/min[b]		

(a) From Calibration Tables for Calibration Orifice or Venturi Tube
(b) From Calibration Tables for Venturi Tube in each Hi-Vol unit. Date check by_____ Date _____

FIGURE 3. EXAMPLE SAMPLING DATA SHEET



(a) ALUMINA COLUMN



(b) SILICA GEL COLUMN

FIGURE 4. MULTILAYERED EXTRACT CLEANUP COLUMNS

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METHOD TO-13

THE DETERMINATION OF BENZO(a)PYRENE [B(a)P] AND OTHER POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs) IN AMBIENT AIR USING GAS CHROMATOGRAPHIC (GC) AND HIGH PERFORMANCE LIQUID CHROMATOGRAPHIC (HPLC) ANALYSIS

1. Scope

1.1 Polynuclear aromatic hydrocarbons (PAHs) have received increased attention in recent years in air pollution studies because some of these compounds are highly carcinogenic or mutagenic. In particular, benzo[a]pyrene (B[a]P) has been identified as being highly carcinogenic. To understand the extent of human exposure to B[a]P, and other PAHs, a reliable sampling and analytical method has been established. This document describes a sampling and analysis procedure for B[a]P and other PAHs involving a combination quartz filter/adsorbent cartridge with subsequent analysis by gas chromatography (GC) with flame ionization (FI) and mass spectrometry (MS) detection (GC/FI and GC/MS) or high resolution liquid chromatography (HPLC). The analytical methods are a modification of EPA Test Method 610 and 625, Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, and Methods 8000, 8270, and 8310, Test Methods for Evaluation of Solid Waste.

1.2 Fluorescence methods were among the very first methods used for detection of B[a]P and other PAHs as a carcinogenic constituent of coal tar (1-7). Fluorescent methods are capable of measuring subnanogram quantities of PAHs, but tend to be fairly non-selective. The normal spectra obtained tended to be intense and lacked resolution. Efforts to overcome this difficulty led to the use of ultraviolet (UV) absorption spectroscopy as the detection method coupled with pre-speciated techniques involving liquid chromatography (LC) and thin layer chromatography (TLC) to isolate specific PAHs, particularly B[a]P (8). As with fluorescence spectroscopy, the individual spectra for various PAHs are unique, although portions of spectra for different compounds may be the same. As with fluoresence techniques, the possibility of spectra overlap required complete separation of sample components to insure accurate measurement of component levels. Hence, the use of UV absorption coupled

with pre-speciation involving LC and TLC and fluorescence spectroscopy has declined and is now being replaced with the more sensitive high performance liquid chromatography (9) with UV/fluorescence detection and highly sensitive and specific gas chromatograph with either flame ionization detector or coupled with mass spectroscopy (10-11).

1.3 The choice of GC and HPLC as the recommended procedures for analysis of B[a]P and other PAHs are influenced by their sensitivity and selectivity, along with their ability to analyze complex samples. This method provides for both GC and HPLC approaches to the determination of B[a]P and other PAHs in the extracted sample.

1.4 The analytical methodology is well defined, but the sampling procedures can reduce the validity of the analytical results. Recent studies (12-15) have indicated that non-volatile PAHs (vapor pressure $<10^{-8}$ mm Hg) may be trapped on the filter, but post-collection volatilization problems may distribute the PAHs down stream of the the filter to the back-up adsorbent. A wide variety of adsorbents such as Tenax GC, XAD-2 resin and polyurethane foam (PUF) have been used to sample B[a]P and other PAH vapors. All adsorbents have demonstrated high collection efficiency for B[a]P in particular. In general, XAD-2 resin has a higher collection efficiency (16-17) for volatile PAHs than PUF, as well as a higher retention efficiency. However, PUF cartridges are easier to handle in the field and maintain better flow characteristics during sampling. Likewise, PUF has demonstrated its capability in sampling organochlorine pesticides and polychlorinated biphenyls (Compendium Methods TO4 and TO10 respectively), and polychlorinated dibenzo-p-dioxins (Compendium Method TO9). However, PUF has demonstrated a lower recovery efficiency and storage capability for naphthalene and B[a]P, respectively, than XAD-2. There have been no significant losses of PAHs, up to 30 days of storage at 0°C, using XAD-2. It also appears that XAD-2 resin has a higher collection efficiency for volatile PAHs than PUF, as well as a higher retention efficiency for both volatile and reactive PAHs. Consequently, while the literature cites weaknesses and strengths of using either XAD-2 or PUF, this method covers both the utilization of XAD-2 and PUF as the adsorbent to address post-collection volatilization problems associated with B[a]P and other reactive PAHs.

1.5 This method covers the determination of B[a]P specificially by both GC and HPLC and enables the qualitative and quantitative analysis of the other PAHs. They are:

Acenaphthene	Benzo(k)fluoranthene
Acenaphthylene	Chrysene
Anthracene	Dibenzo(a,h)anthracene
Benzo(a)anthracene	Fluoranthene
Benzo(a)pyrene	Fluorene
Benzo(b)fluoranthene	Indeno(1,2,3-cd)pyrene
Benzo(e)pyrene	Naphthalene
Benzo(g,h,i)perylene	Phenanthrene
	Pyrene

The GC and HPLC methods are applicable to the determination of PAHs compounds involving two-member rings or higher. Nitro-PAHs have not been fully evaluated using this procedure; therefore, they are not included in this method. When either of the methods are used to analyze unfamiliar samples for any or all of the compounds listed above, compound identification should be supported by both techniques.

1.6 With careful attention to reagent purity and optimized analytical conditions, the detection limits for GC and HPLC methods range from 1 ng to 10 pg which represents detection of B[a]P and other PAHs in filtered air at levels below 100 pg/m^3. To obtain this detection limit, at least 100 m^3 of air must be sampled.

2. Applicable Documents

2.1 ASTM Standards

2.1.1 Method D1356 - Definitions of Terms Relating to Atmospheric Sampling and Analysis.

2.1.2 Method E260 - Recommended Practice for General Gas Chromatography Procedures.

2.1.3 Method E355 - Practice for Gas Chromatography Terms and Relationships.

2.1.4 Method E682 - Practice for Liquid Chromatography Terms and Relationships.

2.1.5 Method D-1605-60 - Standard Recommended Practices for Sampling Atmospheres for Analysis of Gases and Vapors.

2.2 Other Documents

2.2.1 Existing Procedures (18-25)

2.2.2 Ambient Air Studies (26-28)

2.2.3 U.S. EPA Technical Assistance Document (29-32)

2.2.4 General Metal Works Operating Procedures for Model PS-1 Sampler, General Metal Works, Inc., Village of Cleves, Ohio.

3. Summary of Method

3.1 Filters and adsorbent cartridges (containing XAD-2 or PUF) are cleaned in solvents and vacuum-dried. The filters and adsorbent cartridges are stored in screw-capped jars wrapped in aluminum foil (or otherwise protected from light) before careful installation on a modified high volume sampler.

3.2 Approximately 325 m^3 of ambient air is drawn through the filter and adsorbent cartridge using a calibrated General Metal Works Model PS-1 Sampler, or equivalent (breakthrough has not shown to be a problem with sampling volumes of 325 m^3).

3.3 The amount of air sampled through the filter and adsorbent cartridge is recorded, and the filter and cartridge are placed in an appropriately labeled container and shipped along with blank filter and adsorbent cartridges to the analytical laboratory for analysis.

3.4 The filters and adsorbent cartridge are extracted by Soxhlet extraction with appropriate solvent. The extract is concentrated by Kuderna-Danish (K-D) evaporator, followed by silica gel clean-up using column chromatography to remove potential interferences prior to analysis.

3.5 The eluent is further concentrated by K-D evaporator, then analyzed by either gas chromatograhy equipped with FI or MS detection or high performance liquid chromatography (HPLC). The analytical system is verified to be operating properly and calibrated with five concentration calibration solutions, each analyzed in triplicate.

3.6 A preliminary analysis of the sample extract is performed to check the system performance and to ensure that the samples are within the calibration range of the instrument. If necessary, recalibrate the instrument, adjust the amount of the sample injected, adjust the calibration solution concentration, and adjust the data processing system to reflect observed retention times, etc.

3.7 The samples and the blanks are analyzed and used (along with the amount of air sampled) to calculated the concentratuon of B[a]P in ambient air.

3.8 Other PAHs can be determined both qualitatively and quantitatively through optimization of the GC or HPLC procedures.

4. Significance

4.1 Several documents have been published which describe sampling and analytical approaches for benzo[a]pyrene and other PAHs, as outlined in Section 2.2. The attractive features of these methods have been combined in this procedure. This method has been validated in the laboratory; however, one must use caution when employing it for specific applications.

4.2 The relatively low level of B[a]P and other PAHs in the environment requires use of high volume (~6.7 cfm) sampling techniques to acquire sufficient sample for analysis. However, the volatility of certain PAHs prevents efficient collection on filter media alone. Consequently, this method utilizes both a filter and a backup adsorbent cartridge which provide for efficient collection of most PAHs.

5. Definitions

Definitions used in this document and in any user-prepared standard operating procedures (SOPs) should be consistent with ASTM Methods D1356, D1605-60, E260, and E255. All abbreviations and symbols are defined within this document at point of use.

5.1 Sampling efficiency (SE) - ability of the sampling medium to trap vapors of interest. %SE is the percentage of the analyte of interest colleted and retained by the sampling medium when it is introduced as a vapor in air or nitrogen into the air sampler and the sampler is operated under normal conditions for a period of time equal to or greater than that required for the intended use.

5.2 Retention time (RT) - time to elute a specific chemical from a chromatographic column. For a specific carrier gas flow rate, RT is measured from the time the chemical is injected into the gas stream until it appears at the detector.

5.3 High Performance Liquid Chromatography - an analytical method based on separation of compounds of a liquid mixture through a liquid chromatographic column and measuring the separated components with a suitable detector.

5.4 Gradient elution - defined as increasing the strength of the mobile phase during a chromatographic analysis. The net effect of gradient elution is to shorten the retention time of compounds strongly retained on the analytical column. Gradient elution may be stepwise on continuous.

5.5 Method detection limit (MDL) - the minimum concentration of a substance that can be measured and reported with confidence and that the value is above zero.

5.6 Kuderna-Danish apparatus - the Kuderna-Danish (KD) appartus is a system for concentrating materials dissolved in volatile solvents.

5.7 Reverse phase liquid chromatography - reverse phase liquid chromatography involves a non-polar absorbent (C-18,ODS) coupled with a polar solvent to separate non-polar compounds.

5.8 Guard column - guard columns in HPLC are usually short (5cm) columns attached after the injection port and before the analytial column to prevent particles and strongly retained compounds from accumulating on the analytical column. The guard column should always be the same stationary phase as the analytical column and is used to extend the life of the analytical column.

5.9 MS-SIM - the GC is coupled to a select ion mode (SIM) detector where the instrument is programmed to acquire data for only the target compounds and to disregard all others. This is performed using SIM coupled to retention time discriminators. The SIM analysis procedure provides quantitative results.

5.10 Sublimation - Sublimation is the direct passage of a substance from the solid state to the gaseous state and back into the solid form without at any time appearing in the liquid state. Also applied to the conversion of solid to vapor without the later return to solid state, and to a conversion directly from the vapor phase to the solid state.

5.11 Surrogate standard - A surrogate standard is a chemically inert compound (not expected to occur in the environmental sample) which is added to each sample, blank and matrix spiked sample before extraction and analysis. The recovery of the surrogate standard is used to monitor unusual matrix effects, gross sample processing errors, etc. Surrogate recovery is evaluated for acceptance by determining whether the measured concentration falls within acceptable limits.

5.12 Retention time window - Retention time window is determined for each analyte of interest and is the time from injection to elution of a specific chemical from a chromatographic column. The window is determined by three injections of a single component standard over a 72-hr period as plus or minus three times the standard deviation of the absolute retention time for that analyte.

6. Interferences

6.1 Method interferences may be caused by contaminants in solvents, reagents, glassware, and other sample processing hardware that result in discrete artifacts and/or elevated baselines in the detector profiles. All of these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis by running laboratory reagent blanks.

6.1.1 Glassware must be scrupulously cleaned (33). Clean all glassware as soon as possible after use by rinsing with the last solvent used in it. This should be followed by detergent washing with hot water, and rinsing with tap water and reagent water. It should then be drained dry, solvent rinsed with acetone and spectrographic grade hexane. After drying and rinsing, glassware should be sealed and stored in a clean environment to prevent any accumulation of dust or other contaminants. Glassware should be stored inverted or capped with aluminum foil.

6.1.2 The use of high purity water, reagents and solvents helps to minimize interference problems. Purification of solvents by distillation in all-glass systems may be required.

6.1.3 Matrix interferences may be caused by contaminants that are coextracted from the sample. Additional clean-up by column chromatography may be required (see Section 12.4).

6.2 The extent of interferences that may be encountered using liquid chromatographic techniques has not been fully assessed. Although GC and HPLC conditions described allow for unique resolution of the specific PAH compounds covered by this method, other PAH compounds may interfere. The use of column chromatography for sample clean-up prior to GC or HPLC analysis will eliminate most

of these interferences. The analytical system must, however, be routinely demonstrated to be free of internal contaminants such as contaminated solvents, glassware, or other reagents which may lead to method interferences. A laboratory reagent blank is run for each batch of reagents used to determine if reagents are contaminant-free.

6.3 Although HPLC separations have been improved by recent advances in column technology and instrumentation, problems may occur with baseline noise, baseline drift, peak resolution and changes in sensitivity. Problems affecting overall system performance can arise (34). The user is encouraged to develop a standard operating procedure (SOP) manual specific for his laboratory to minimize problems affecting overall system performance.

6.4 Concern during sample transport and analysis is mentioned. Heat, ozone, NO_2 and ultraviolet (UV) light may cause sample degradation. These problems should be addressed as part of the user prepared standard operating procedure manual. Where possible, incandescent or UV-shield fluorescent lighting should be used during analysis.

7. Safety

7.1 The toxicity or carcinogenicity of each reagent used in this method has not been precisely defined; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. The laboratory is responsible for maintaining a current awareness file of Occupational Safety and Health Administration (OSHA) regulations regarding the safe handling of the chemicals specified in this method. A reference file of material data handling sheets should also be made available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available and have been identified for the analyst (35-37).

7.2 Benzo[a]pyrene has been tentatively classified as a known or suspected, human or mammalian carcinogen. Many of the other PAHs have been classified as carcinogens. Care must be exercised when

working with these substances. This method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. The user should be thoroughly familiar with the chemical and physical properties of targeted substances (Table 1.0 and Figure 1.0).

7.3 Treat all selective polynuclear aromatic hydrocarbons as carcinogens. Neat compounds should be weighed in a glove box. Spent samples and unused standards are toxic waste and should be disposed according to regulations. Regularly check counter tops and equipment with "black light" for fluorescence as an indicator of contamination.

7.4 Because the sampling configuration (filter and backup adsorbent) has demonstrated greater than 95% collection efficiency for targeted PAHs, no field recovery evaluation will occur as part of this procedure.

8. Apparatus

8.1 Sample Collection

8.1.1 General Metal Works (GMW) Model PS-1 Sampler, or equivalent [General Metal Works, Inc., 145 South Miami Ave., Village of Cleves, Ohio, 45002, (800-543-7412)].

8.1.2 At least two Model PS-1 sample cartridges and filters assembled for PS-1 sampler.

8.1.3 GMW Model PS-1 calibrator and associated equipment - General Metal Works, Inc., Model GMW-40, 145 South Miami Ave., Village of Cleves, Ohio, 45002, (800-543-7412).

8.1.4 Ice chest - to store samples at 0°C after collection.

8.1.5 Data sheets for each sample for recording the location and sample time, duration of sample, starting time, and volume of air sampled.

8.1.6 Airtight, labeled screw-capped container sample cartridges (wide mouth, preferrably glass with Teflon seal or other non-contaminating seals) to hold filter and adsorbent cartridge during transport to analytical laboratory.

8.1.7 Portable Tripod Sampler (optional) - user prepared (38).

8.2 Sample Clean-up and Concentration

8.2.1 Soxhlet extractors capable of extracting GMW Model PS-1 filter and adsorbent cartridges (2.3" x 5" length), 500 mL flask, and condenser.

8.2.2 Pyrex glass tube furnace system for activating silica gel at 180°C under purified nitrogen gas purge for an hour, with capability of raising temperature gradually.

8.2.3 Glass vial, 40 mL.

8.2.4 Erlenmeyer flask, 50 mL - best source. [Note: Reuse of glassware should be minimized to avoid the risk of cross-contamination. All glassware that is used, especially glassware that is reused, must be scrupulously cleaned as soon as possible after use. Rinse glassware with the last solvent used in it and then with high-purity acetone and hexane. Wash with hot water containing detergent. Rinse with copious amount of tap water and several portions of distilled water. Drain, dry, and heat a muffle furnace at 400°C for 2 to 4 hours. Volumetric glassware must not be heated in a muffle furnace; rather, it should be rinsed with high-purity acetone and hexane. After the glassware is dry and cool, rinse it with hexane, and store it inverted or capped with solvent-rinsed aluminum foil in a clean environment.]

8.2.5 Polyester gloves for handling cartridges and filters.

8.2.6 Minivials - 2 mL, borosilicate glass, with conical reservoir and screw caps lines with Teflon-faced silicone disks, and a vial holder.

8.2.7 Stainless steel Teflon® coated spatulas and spoons.

8.2.8 Kuderna-Danish (KD) apparatus - 500 mL evaporation flask (Kontes K-570001-500 or equivalent), 10 mL graduated concentrator tubes (Knotes K-570050-1025 or equivalent) with ground-glass stoppers, and 3-ball macro Snyder column (Kontes K-5700010500, K-50300-0121, and K-569001-219, or equivalent).

8.2.9 Adsorption columns for column chromatography - 1-cm x 10-cm with stands.

8.2.10 Glove box for working with extremely toxic standards and reagents with explosion-proof hood for venting fumes from solvents, reagents, etc.

8.2.11 Vacuum Oven - Vacuum drying oven system capable of maintaining a vacuum at 240 torr (flushed with nitrogen) overnight.

8.2.12 Concentrator tubes and a nitrogen evaporation apparatus with variable flow rate - best source.

8.2.13 Laboratory refrigerator with chambers operating at 0°C and 4°C.

8.2.14 Boiling chips - solvent extracted, 10/40 mesh silicon carbide or equivalent.

8.2.15 Water bath - heated, with concentric ring cover, capable of temperature control (± 5°C).

8.2.16 Vortex evaporator (optional).

8.3 Sample Analysis

8.3.1 Gas Chromatography with Flame Ionization Detection (FID).

8.3.1.1 Gas chromatography: Analytical system complete with gas chromatography suitable for on-column injections and all required accessories, including detectors, column supplies, recorder, gases, and syringes. A data system for measuring peak areas and/or peak heights is recommended.

8.3.1.2 Packed Column: 1.8-m x 2-mm I.D. glass column packed with 3% OV-17 on Chromosorb W-AW-DMCS (100/120 mesh) or equivalent (Supelco Inc., Supelco Park, Bellefonte, Pa. Supelco SPB-5).

8.3.1.3 Capillary Column: 30-m x 0.25-mm ID fused silica column coated with 0.25 u thickness 5% phenyl, 90% methyl siloxane (Supelco Inc., Supelco Park, Bellefonte, Pa.).

8.3.1.4 Detector: Flame Ionization (FI)

8.3.2 Gas Chromatograph with Mass Spectroscopy Detection Coupled with Data Processing System (GC/MS/DS).

8.3.2.1 The GC must be equipped for temperature programming, and all required accessories must be available, including syringes, gases, and a capillary column. The GC injection port must be designed for capillary columns. The use of splitless injection techniques is recommended. On-column injection techniques can be used but they may severely reduce column lifetime for nonchemically bonded columns. In this protocol, a 1-3 uL injection volume is used consistently. With some GC injection ports, however, 1 uL injections may produce some improvement in precision and chromatographic

separation. A 1 uL injection volume may be used if adequate sensitivity and precision can be achieved. [NOTE: If 1 uL is used as the injection volume, the injection volumes for all extracts, blanks, calibration solutions and performance check samples must be 1 uL.]

8.3.2.2 Gas Chromatograph-Mass Spectrometer Interface. The gas chromatograph is usually coupled directly to the mass spectrometer source. The interface may include a diverter valve for shunting the column effluent and isolating the mass spectrometer source. All components of the interface should be glass or glass-lined stainless steel. The interface components should be compatible with 320°C temperatures. Cold spots and/or active surfaces (adsorption sites) in the GC/MS interface can cause peak tailing and peak broadening. It is recommended that the GC column be fitted directly into the MS source. Graphic ferrules should be avoided in the GC injection area since they may adsorb PAHs. Vespel® or equivalent ferrules are recommended.

8.3.2.3 Mass Spectrometer. The static resolution of the instrument must be maintained at a minimum of 10,000 (10 percent valley). The mass spectrometer should be operated in the selected ion mode (SIM) with a total cycle time (including voltage reset time) of one second or less (Section 14.2).

8.3.2.4 Mass spectrometer: Capable of scanning from 35 to 500 amu every 1 sec or less, using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer must be capable of producing a mass spectrum for decafluorotriphenylphosphine (DFTPP) which meets all of the criteria (Section 14.5.1).

8.3.2.5 Data System. A dedicated computer data system is employed to control the rapid multiple ion monitoring process and to acquire the data. Quantification data (peak areas or peak heights) and multi-ion detector (MID) traces (displays of intensities of each m/z being monitored

as a function of time) must be acquired during the analyses. Quantifications may be reported based upon computer-generated peak areas or upon measured peak heights (chart recording). The detector zero setting must allow peak-to-peak measurement of the noise on the baseline.

8.3.2.6 GC Column. A fused silica column (50-m x 0.25-mm I.D.) HP Ultra #2 crosslinked 5% phenyl methylsilicone, 0.25 um film thickness (Hewlett-Packard Co., Crystal Lake, IL) is utilized to separate individual PAHs. Other columns may be used for determination of PAHs. Minimum acceptance criteria must be determined as per Section 14.2. At the beginning of each 12-hour period (after mass resolution has been demonstrated) during which sample extracts or concentration calibration solutions will be analyzed, column operating conditions must be attained for the required separation on the column to be used for samples.

8.3.2.7 Balance - Mettler balance or equivalent.

8.3.2.8 All required syringes, gases, and other pertinent supplies to operate the GC/MS system.

8.3.2.9 Pipettes, micropipettes, syringes, burets, etc., to make calibration and spiking solutions, dilute samples if necessary, etc., including syringes for accurately measuring volumes such as 25 uL and 100 uL.

8.3.3 High Performance Liquid Chromatography (HPLC) System.

8.3.3.1 Gradient HPLC system - Consisting of acetonitrile and water phase reservoirs; mixing chamber; a high pressure pump; an injection valve (automatic sampler with an optional 25 uL loop injector); a Vydac C-18 bonded phase reverse phase (RP) column, (The Separations Group, P.O. Box 867, Hesperia, CA 92345) or equivalent (25-cm x 4.6-mm ID); a variable wavelength UV/Fluorescence detector and a data system or strip chart recorder. A Spectra Physics 8100 liquid chromatograph multi-microprocessor controlled, with ternary gradient pumping system, constant flow, autosampler injector (10 uL injection loop), and column oven (optional).

8.3.3.2 Guard column - 5-cm guard column pack with Vydac reverse phase C-18 material.

8.3.3.3 Reverse phase analytical column - Vydac or equivalent, C-18 bonded phase RP column (The Separation Group, P.O. Box 867, Hesperia, Ca., 92345), 4.6-mm x 25-cm, 5-micron particle diameter.

8.3.3.4 LS-4 fluorescence spectrometer, Perkin Elmer, separate excitation and emission, monochromator positioned by separate microprocessor-controlled flow cell and wavelength programming ability (optional).

8.3.3.5 Ultraviolet/visible detector, Spectra Physics 8440, deuterium Lamp, capable of programmable wavelengths (optional).

8.3.3.6 Dual channel Spectra Physics 4200 Computing Integrator, measures peak areas and retention times from recorded chromatographs. IBM PC XT will Spectra Physics Labnet system for data collection and storage (optional).

9. Reagents and Materials

9.1 Sample Collection

9.1.1 Acid-washed quartz fiber filter - 105 mm micro quartz fiber binderless filter (General Metal Works, Inc., Cat. No. GMW QMA-4, 145 South Miami Ave., Village of Cleves, Ohio, 45002 [800-543-7412] or Supelco Inc., Cat. No. 1-62, Supelco Park, Bellefonte, PA, 16823-0048).

9.1.2 Polyurethane foam (PUF) - 3 inch thick sheet stock, polyether type (density 0.022 g/cm^3) used in furniture upholstering (General Metal Works, Inc., Cat. No. PS-1-16, 145 South Miami Ave., Village of Cleves, Ohio, 45002 [800-543-7412] or Supelco Inc., Cat. No. 1-63, Supelco Park, Bellefonte, PA, 16823-0048).

9.1.3 XAD-2 resin - Supelco Inc., Cat. No. 2-02-79, Supelco Park, Bellefonte, PA, 16823-0048.

9.1.4 Hexane-rinsed aluminum foil - best source.

9.1.5 Hexane-reagent grade, best source.

9.2 Sample Clean-up and Concentration

9.2.1 Soxhlet Extraction

9.2.1.1 Methylene chloride - chromatographic grade, glass-distilled, best source.

9.2.1.2 Sodium sulfate, anhydrous - (ACS) granular anhydrous (purified by washing with methylene chloride followed by heating at 400°C for 4 hrs in a shallow tray).

9.2.1.3 Boiling chips - solvent extracted, approximately 10/40 mesh (silicon carbide or equivalent).

9.2.1.4 Nitrogen - high purity grade, best source.

9.2.1.5 Ether - chromatographic grade, glass-distilled, best source.

9.2.1.6 Hexane - chromatographic grade, glass-distilled, best source.

9.2.1.7 Dibromobiphenyl - chromatographic grade, best source. Used for internal standard.

9.2.1.8 Decafluorobiphenyl - chromatographic grade, best source. Used for internal standard.

9.2.2 Solvent Exchange

9.2.2.1 Cyclohexane - chromatographic grade, glass-distilled, best source.

9.2.3 Column Clean-up

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9.2.3.1 Silica gel - high purity grade, type 60, 70-230 mesh; extracted in a Soxhlet apparatus with methylene chloride for 6 hours (minimum of 3 cycles per hour) and activated by heating in a foil-covered glass container for 24 hours at 130°C.

9.2.3.2 Sodium sulfate, anhydrous - (ACS) granular anhydrous (See Section 9.2.1.2).

9.2.3.3 Pentane - chromatographic grade, glass-distilled, best source.

Lobar Prepacked Column

9.2.3.4 Silica gel lobar prepacked column - E. Merck, Darmstadt, Germany [Size A(240-10) Lichroprep Si (40-63 um)].

9.2.3.5 Precolumn containing sodium sulfate - American Chemical Society (ACS) granular anhydrous (purified by washing with methylene chloride followed by heating at 400°C for 4 hours in a shallow tray).

9.2.3.6 Hexane - chromatographic grade, glass-distilled, best source.

9.2.3.7 Methylene chloride - chromatographic grade, glass-distilled, best source

9.2.3.8 Methanol - chromatographic grade, glass-distilled, best source.

9.3 Sample Analysis

9.3.1 Gas Chromatography Detection

9.3.1.1 Gas cylinders of hydrogen and helium - ultra high purity, best source.

9.3.1.2 Combustion air - ultra high purity, best source.

9.3.1.3 Zero air - Zero air may be obtained from a cylinder or zero-grade compressed air scrubbed with Drierite® or silica gel and 5A molecular sieve or activated charcoal, or by catalytic cleanup of ambient air. All zero air should be passed through a liquid argon cold trap for final cleanup.

9.3.1.4 Chromatographic-grade stainless steel tubing and stainless steel plumbing fittings - for interconnections. [Alltech Applied Science, 2051 Waukegan Road, Deerfield, IL, 60015, (312) 948-8600]. [Note: All such materials in contact with the sample, analyte, or support gases prior to analysis should be stainless steel or other inert metal. Do not use plastic or Teflon® tubing or fittings.]

9.3.1.5 Native and isotopically labeled PAHs isomers for calibration and spiking standards-[Cambridge Isotopes, 20 Commerce Way, Woburn, MA, 01801 (617-547-1818)]. Suggested isotopically labeled PAH isomers are:

- o perylene - d_{12}
- o chrysene - d_{12}
- o acenaphthene - d_{10}
- o naphthalene - d_8
- o phenanthrene - d_{10}

9.3.1.6 Decafluorotriphenylphosphine (DFTPP) - best source, used for tuning GC/MS.

9.3.2 High Performance Liquid Chromatography Detection

9.3.2.1 Acetonitrile - chromatographic grade, glass-distilled, best source.

9.3.2.2 Boiling chips - solvent extracted, approximatley 10/40 mesh (silicon carbide or equivalent).

9.3.2.3 Water - HPLC Grade. Water must not have an interference that is observed at the minimum detectable limit (MDL) of each parameter of interest.

9.3.2.4 Decafluorobiphenyl - HPLC grade, best source (used for internal standard).

10. Preparation of Sample Filter and Adsorbent

10.1 Sampling Head Configuration

10.1.1 The sampling head (Figure 2) consist of a filter holder compartment followed by a glass cartridge for retaining the adsorbent.

10.1.2 Before field use, both the filter and adsorbent must be cleaned to <10 ng/apparatus of B[a]P or other PAHs.

10.2 Glass Fiber Filter Preparation

10.2.1 The glass fiber filters are baked at 600°C for five hours before use. To insure acceptable filters, they are extracted with methylene chloride in a Soxhlet apparatus, similar to the cleaning of the XAD-2 resin (see Section 10.3).

10.2.2 The extract is concentrated and analyzed by either GC or HPLC. A filter blank of <10 ng/filter of B[a]P or other PAHs is considered acceptable for field use.

10.3 XAD-2 Adsorbent Preparation

10.3.1 For initial cleanup of the XAD-2, a batch of XAD-2 (approximately 60 grams) is placed in a Soxhlet apparatus [see Figure 3(a)] and extracted with methylene chloride for 16 hours at approximately 4 cycles per hour.

10.3.2 At the end of the initial Soxhlet extraction, the spent methylene chloride is discarded and replaced with fresh reagent. The XAD-2 resin is once again extracted for 16 hours at approximately 4 cycles per hour.

10.3.3 The XAD-2 resin is removed from the Soxhlet apparatus, places in a vacuum oven connected to an ultra-purge nitrogen gas stream and dries at room temperature for approximately 2-4 hours (until no solvent odor is detected).

10.3.4 A nickel screen (mesh size 200/200) is fitted to the bottom of a hexane-rinsed glass cartridge to retain the XAD-2 resin.

10.3.5 The Soxhlet extracted/vacuum dried XAD-2 resin is placed into the sampling cartridge (using polyester gloves) to a depth of approximately 2 inches. This should require approximately 55 grams of adsorbent.

10.3.6 The glass module containing the XAD-2 adsorbent is wrapped with hexane-rinsed aluminum foil, placed in a labeled container and tightly sealed with Teflon® tape.

10.3.7 At least one assemble cartridge from each batch must be analyzed, as a laboratory blank, using the procedures described in Section 13, before the batch is considered acceptable for field use. A blank of <10 ng/cartridge of B[a]P on other PNA's is considered acceptable.

10.4 PUF Sampling Cartridge Preparation

10.4.1 The PUF adsorbent is a polyether-type polyurethane foam (density No. 3014 or 0.0225 g/cm^3) used for furniture upholstery.

10.4.2 The PUF inserts are 6.0-cm diameter cylindrical plugs cut from 3-inch sheet stock and should fit, with slight compression, in the glass cartridge, supported by the wire screen (see Figure 1). During cutting, the die is rotated at high speed (e.g., in a drill press) and continuously lubricated with water.

10.4.3 For initial cleanup, the PUF plug is placed in a Soxhlet apparatus [see Figure 3(a)] and extracted with acetone for 14-24 hours at approximately 4 cycles per hour. [Note: When cartridges are reused, 5% diethyl ether in n-hexane can be used as the cleanup solvent.]

10.4.4 The extracted PUF is placed in a vacuum oven connected to a water aspirator and dried at room temperature for approximately 2-4 hours (until no solvent odor is detected).

10.4.5 The PUF is placed into the glass sampling cartridge using polyester gloves. The module is wrapped with hexane-rinsed aluminum foil, placed in a labeled container, and tightly sealed.

10.4.6 At least one assembled cartridge from each batch must be analyzed, as a laboratory blank, using the procedures described in Section 13, before the batch is considered acceptable for field use. A blank level of <10 ng/plug for single compounds is considered to be acceptable.

11. Sample Collection

11.1 Description of Sampling Apparatus

11.1.1 The entire sampling system can be a modification of a traditional high volume sampler (see Figure 4) or a portable sampler (see Figure 5). A unit specifically designed for this method is commercially available (Model PS-1 - General Metal Works, Inc., Village of Cleves, Ohio).

11.1.2 The sampling module consists of a glass sampling cartridge and an air-tight metal cartridge holder, as outlined in Section 10.1. The adsorbent (XAD-2 or PUF) is retained in the glass sampling cartridge.

11.2 Calibration of Sampling System

Each sampler is to be calibrated: 1) when new; 2) after major repairs or maintenance; 3) whenever any audit point deviates from the calibration curve by more than 7%; 4) when a different sample collection media, other than that which the sampler was originally calibrated to, will be used for sampling; or 5) at the frequency specified in the user Standard Operating Procedure (SOP) manual in which the samplers are utilized.

11.2.1 Calibration of Flow Rate Transfer Standard

Calibration of the modified high volume air sampler in the field is performed using a calibrated orifice flow rate transfer standard. The flow rate transfer standard must be certified in the laboratory against a positive displacement rootsmeter (see Figure 6). Once certified, the recertification is performed rather infrequently if the orifice is protected from damage. Recertification of the orifice flow rate transfer standard is performed once per year utilizing a set of five (5) multihole resistance plates. [Note: The 5 multihole resistance plates are used to change the flow through the orifice so that several points can be obtained for the orifice calibration curve.]

11.2.1.1 Record the room temperature (t_1 in °C) and barometric pressure (P_b in mm Hg) on Orifice Calibration Data Sheet (see Figure 7). Calculate the room temperature in °K (absolute temperature) and record on Orifice Calibration Data Sheet.

$$t_1 \text{ in K} = 273° + t_1 \text{ in °C}$$

11.2.1.2 Set up laboratory orifice calibration equipment as illustrated in Figure 6. Check the oil level of the rootsmeter prior to starting. There are three oil level indicators, one at the clear plastic end, and two sight glasses, one at each end of the measuring chamber.

11.2.1.3 Check for leaks by clamping both manometer lines blocking the orifice with cellophane tape, turning on the high volume motor, and noting any change in the rootsmeter's reading. If the rootsmeter's reading changes, then there is a leak in the system or in the tape. Eliminate the leak before proceeding. If the rootsmeter's reading remains constant, turn off the hi-vol motor, remove the cellophane tape, and unclamp both manometer lines.

11.2.1.4 Install the 5-hole resistance plate between the orifice and the filter adapter.

11.2.1.5 Turn manometer tubing connectors one turn counterclockwise. Make sure all connectors are open.

11.2.1.6 Adjust both manometer midpoints by sliding their movable scales until the zero point corresponds with the bottom of the meniscus. Gently shake or tap to remove any air bubbles and/or liquid remaining on tubing connectors. (If additional liquid is required for the water manometer, remove tubing connector and add clean water).

11.2.1.7 Turn on the hi-vol motor and let it run for five minutes to set the motor brushes.

11.2.1.8 Record both manometer readings-orifice water manometer (ΔH) and rootsmeter mercury manometer (ΔP). [Note: ΔH is the sum of the difference from zero (0) of the two column heights.]

11.2.1.9 Record the time, in minutes, required to pass a known volume of air (approximately 200-300 ft^3 of air for each resistance plate) through the rootsmeter by using the rootsmeter's digital volume dial and a stopwatch.

11.2.1.10 Turn off the high volume motor.

11.2.1.11 Replace the 5-hole resistance plate with the 7-hole resistance plate.

11.2.1.12 Repeat Sections 11.2.1.3 through 11.2.1.10.

11.2.1.13 Repeat for each resistance plate. Note results on Orifice Calibration Data Sheet (see Figure 7). Only a minute is needed for warm-up of the motor. Be sure to tighten the orifice enough to eliminate any leaks. Also check the gaskets for cracks. [Note: The placement of the orifice prior to the rootsmeter causes the pressure at the inlet of the rootsmeter to be reduced below atmospheric conditions, thus causing the measured volume to be incorrect. The volume measured by the rootsmeter must be corrected.]

11.2.1.14 Correct the measured volumes with the following formula and record the standard volume on the Orifice Calibration Data Sheet:

$$V_{std} = V_m \frac{P_1 - \Delta P}{P_{std}} \frac{T_{std}}{T_1}$$

where: V_{std} = standard volume (std m^3).

V_m = actual volume measured by the rootsmeter (m^3).

P_1 = barometric pressure during calibration (mm Hg).

ΔP = differential pressure at inlet to volume meter (mm Hg).

P_{std} = 760 mm Hg.

T_{std} = 298 K.

T_1 = ambient temperature during calibration (K).

11.2.1.15 Record standard volume on Orifice Calibration Data Sheet.

11.2.1.16 The standard flow rate as measured by the rootsmeter can now be calculated using the following formula:

$$Q_{std} = \frac{V_{std}}{\theta}$$

where: Q_{std} = standard volumetric flow rate, std m^3/min.

θ = elapsed time, min.

11.2.1.17 Record the standard flow rates to the nearest 0.01 std m^3/min.

11.2.1.18 Calculate and record $\sqrt{\Delta H(P_1/P_{std})\ (298/T_1)}$ value for each standard flow rate.

11.2.1.19 Plot each $\sqrt{\Delta H(P_1/P_{std})\ (298/T_1)}$ value (y-axis) versus its associated standard flow rate (x-axis) on arithmetic graph paper, draw a line of best fit between the individual plotted points and calculate the linear regression slope (M) and intercept (b).

11.2.1.20 Commercially available calibrator kits are available [General Metal Works Inc., Model GMW-40, 145 South Miami Avenue, Village of Cleves, Ohio, 45002 (1-800-543-7412)].

11.2.2 Calibration of The High Volume Sampling System Utilizing Calibrated Multi-point Flow Rate Transfer Standard

11.2.2.1 The airflow through the sampling system can be monitored by a venturi/magnehelic assembly, as illustrated in Figure 4 or by a u-tube assembly connected to the high volume portable design as illustrated in Figure 5. The field sampling system must be audited every six months using a flow rate transfer standard, as described in the U.S. EPA High Volume Sampling Method, 40 CFR 50, Appendix B. A single-point calibration must be performed before and after each sample collection, using a transfer standard calibrated as described in Section 11.2.1.

11.2.2.2 Prior to initial multi-point calibration, a "dummy" adsorbent cartridge and filter are placed in the sampling head and the sampling motor is activated. The flow control valve is fully opened and the voltage variator is adjusted so that a sample flow rate corresponding to 110% of the desired flow rate (typically 0.20 - 0.28 m^3/min) is indicated on the Magnehelic gauge (based on the previously obtained multi-point calibration curve). The

motor is allowed to warm up for 10 minutes and then the flow control valve is adjusted to achieve the desired flow rate. Turn off the sampler. The ambient temperature and barometric pressure should be recorded on the Field Calibration Data Sheet (Figure 9).

11.2.2.3 The flow rate transfer standard is placed on the sampling head, and a manometer is connected to the tap on the transfer standard using a length of tubing. Properly align the retaining rings with filter holder and secure by tightening the three screw clamps. Set the zero level of the manometer. Attach the magnehelic gage to the sampler venturi quick release connections. Adjust the zero (if needed) using the zero adjust screw on the face of the gage.

11.2.2.4 Turn the flow control valve to the fully open position and turn the sampler on. Adjust the flow control valve until a magnehelic reading of approximately 70 in. is obtained. Allow the magnehelic and manometer readings to stabilize and record these values.

11.2.2.5 Adjust the flow control valve and repeat until six or seven uniformally spaced magnehelic readings are recorded spanning the range of approximately 40-70 in. Record the readings on the Field Calibration Data Sheet (see Figure 9). [Note: Use of some filter/sorbent media combinations may restrict the airflow resulting in a maximum magnehelic reading of 60 in. or less. In such cases, a variable transformer should be placed in-line between the 110 volt power source and the sampler so that the line voltage can be increased sufficiently to obtain a maximum magnehelic reading approaching 70 in.].

11.2.2.6 Adjust the orifice manometer reading for standard temperature and pressure using the following equation:

$$X = \sqrt{\Delta H \frac{P_a}{P_{std}} \frac{T_{std}}{T_a}}$$

where: X = adjusted manometer reading to standard temperature and pressure (in. water).

ΔH = observed manometer reading (in water).

P_a = current barometric pressure (mm Hg).

P_{std} = 760 mm Hg.

T_a = current temperature (K), (K = °C + 273).

T_{std} = standard temperature (298 K).

11.2.2.7 Calculate the standard flow rate for each corrected manometer reading by the following equation:

$$Q_{std} = \frac{X - b}{M}$$

where:

Q_{std} = standard flow rate (m^3/min).

M = slope of flow rate transfer standard calibration curve.

X = corrected manometer reading from 11.2.2.6 (in water).

b = intercept of flow rate transfer standard calibration curve.

11.2.2.8 Adjust the magnehelic gage readings to standard temperature and pressure using the following equation:

$$M_{std} = \sqrt{\frac{(M)(P_a)}{P_{std}} \cdot \frac{T_{std}}{T_a}}$$

where:

M_{std} = adjusted magnehelic reading to standard temperature and pressure (inches of water).

M = observed magnehelic reading (inches of water).

P_a = ambient atmospheric pressure (mm Hg).

P_{std} = standard pressure (760 mm Hg).

T_a = ambient temperature (K), (K = °C + 273).

T_{std} = standard temperature (298 K).

11.2.2.9 Plot each M_{std} value (y-axis) versus its associated Q_{std} standard (x-axis) on arithmetic graph paper. Draw a line of best fit between the individual plotted points. This is the calibration curve for the venturi. Retain with sampler.

11.2.2.10 Record the corresponding Q_{std} for each M_{std} under Q_{std} column on Field Calibration Data Sheet, Figure 9.

11.2.3 Single-point Audit of The High Volume Sampling System Utilizing Calibrated Flow Rate Transfer Standard

11.2.3.1 A single point flow audit check is performed before and after each sampling period utilizing the Calibration Flow Rate Transfer Standard (Section 11.2.1).

11.2.3.2 Prior to single point audit, a "dummy" adsorbent cartridge and filter are placed in the sampling head and the sampling motor is activated. The flow control valve is fully opened and the voltage variator is adjusted so that a

sample flow rate corresponding to 110% of the desired flow rate (typically 0.20-0.28 m^3/min) is indicated on the magnehelic gauge (based on the previously obtained multi-point calibration curve). The motor is allowed to warm up for 5 minutes and then the flow control valve is adjusted to achieve the desired flow rate. Turn off the sampler. The ambient temperature and barometric pressure should be recorded on a Field Test Data Sheet (Figure 10).

11.2.3.3 The flow rate transfer standard is placed on the sampling head.

11.2.3.4 Properly align the retaining rings with filter holder and secure by tightening the three screw clamps.

11.2.3.5 Using tubing, attach one manometer connector to the pressure tap of the transfer standard. Leave the other connector open to the atmosphere.

11.2.3.6 Adjust the manometer midpoint by sliding the movable scale until the zero point corresponds with the water meniscus. Gently shake or tap to remove any air bubbles and/or liquid remaining on tubing connectors. (If additional liquid is required, remove tubing connector and add clean water.)

11.2.3.7 Turn on high volume motor and let run for five minutes.

11.2.3.8 Record the pressure differential indicated, ΔH, in inches of water. Be sure stable ΔH has been established.

11.2.3.9 Record the observed magnehelic gauge reading, in inches of water. Be sure stable M has been established.

11.2.3.10 Using previously established Flow Rate Transfer Standard curve, calculate Q_{std} (see steps 11.2.2.6 - 11.2.2.7).

11.2.3.11 Using previously established venturi calibration curve, calculate the indicated Q_{std} (Section 11.2.2.9).

11.2.3.12 A multi-point calibration of the Flow Rate Transfer Standard against a primary standard, must be obtained annually, as outlined in Section 11.2.1.

11.2.3.13 Remove Flow Rate Transfer Standard and dummy adsorbent cartridge and filter assembly.

11.3 Sample Collection

11.3.1 After the sampling system has been assembled and flow checked as described in Sections 11.1 and 11.2, it can be used to collect air samples, as described in Section 11.3.2.

11.3.2 The samples should be located in an unobstructed area, at least two meters from any obstacle to air flow. The exhaust hose should be stretched out in the downwind direction to prevent recycling of air into the sample head.

11.3.3 With the empty sample module removed from the sampler, rinse all sample contact areas using reagent grade hexane in a Teflon® squeeze bottle. Allow the hexane to evaporate from the module before loading the samples.

11.3.4 Detach the lower chamber of the rinsed sampling module. While wearing disposable clean lint-free nylon or powder-free surgical gloves, remove a clean glass cartridge/sorbent from its container (wide mouthed glass jar with a Teflon®-lined lid) and unwrap its aluminum foil covering. The foil should be replaced back in the sample container to be re-used after the sample has been collected.

11.3.5 Insert the cartridge into the lower chamber and tightly reattach it to the module.

11.3.6 Using clean Teflon® tipped forceps, carefully place a clean fiber filter atop the filter holder and secure in place by clamping the filter holder ring over the filter using the three screw clamps. Insure that all module connections are tightly assembled. [Note: Failure to do so

could result in air flow leaks at poorly sealed locations which could affect sample representativeness]. Ideally, sample module loading and unloading should be conducted in a controlled environment or at least a centralized sample processing area so that the sample handling variables can be minimized.

11.3.7 With the module removed from the sampler and the flow control valve fully open, turn the pump on and allow it to warm-up for approximately 5 minutes.

11.3.8 Attach a "dummy" sampling module loaded with the exact same type of filter and sorbent media as that which will be used for sample collection.

11.3.9 With the sampler off, attach the Magnahelic gage to the sampler. Turn the sampler on and adjust the flow control valve to the desired flow (normally as indicated by the cfm; magnahelic gauge reading and reference by the calibration chart. [Note: Breakthrough has not been a problem for all PAHs outlined in Section 1.5 using this sampling method except anthracene and penanthrene]. Once the flow is properly adjusted, extreme care should be taken not to inadvertantly alter its setting.

11.3.10 Turn the smpler off and remove both the "dummy" module and the Magnahelic gauge. The sampler is now ready for field use.

11.3.11 The zero reading of the sampler Magnehelic is checked. Ambient temperature, barometric pressure, elapsed time meter setting, sampler serial number, filter number, and adsorbent sample number are recorded on the Field Test Data Sheet (see Figure 10). Attach the loaded sampler module to the sampler.

11.3.12 The voltage variator and flow control valve are placed at the settings used in Section 11.2.2, and the power switch is turned on. The elapsed time meter is activated and the start time is recorded. The flow (Magnehelic setting) is adjusted, if necessary, using the flow control valve.

11.3.13 The Magnehelic reading is recorded every six hours during the sampling period. The calibration curve

(Section 11.2.4) is used to calculate the flow rate. Ambient temperature, barometric pressure, and Magnehelic reading are recorded at the beginning and end of the sampling period.

11.3.14 At the end of the desired sampling period, the power is turned off. Carefully remove the sampling head containing the filter and adsorbent cartridge to a clean area.

11.3.15 While wearing disposable lint free nylon or surgical gloves, remove the sorbent cartridge from the lower module chamber and lay it on the retained aluminum foil in which the sample was originally wrapped.

11.3.16 Carefully remove the glass fiber filter from the upper chamber using clean Teflon® tiped forceps.

11.3.17 Fold the filter in half twice (sample side inward) and place it in the glass cartridge atop the sorbent.

11.3.18 Wrap the combined samples in aluminum foil and place them in their original glass sample container. A sample label should be completed and affixed to the sample container. Chain-of-custody should be maintained for all samples.

11.3.19 The glass containers should be stored in ice and protected from light to prevent possible photo-decomposition of collected analytes. If the time span between sample collection and laboratory analysis is to exceed 24 hours, sample must be kept refrigerated. [Note: Recent studies (13,16) have indicated that PUF does not retain, during storage, B[a]P as effectively as XAD-2. Therefore, sample holding time should not exceed 20 days.]

11.3.20 A final calculated sample flow check is performed using the calibration orifice, as described in Section 11.2.2. If calibration deviates by more than 10% from the initial reading, the flow data for that sample must be marked as suspect and the sampler should be inspected and/or removed from service.

11.3.21 At least one field filter/adsorbent blank will be returned to the laboratory with each group of samples. A field blank is treated exactly as a sample except that no air is drawn through the filter/adsorbent cartridge assembly.

11.3.22 Samples are stored at 0°C in an ice chest until receipt at the analytical laboratory, after which they are refrigerated at 4°C.

12. Sample Clean-up and Concentration

[Note: The following sample extraction, concentration, solvent exchange and analysis procedures are outlined for user convenience in Figure 11.]

12.1 Sample Identification

12.1.1 The samples are returned in the ice chest to the laboratory in the glass sample container containing the filter and adsorbent.

12.1.2 The samples are logged in the laboratory logbook according to sample location, filter and adsorbent cartridge number identification and total air volume sampled (uncorrected).

12.1.3 If the time span between sample registration and analysis is greater than 24-hrs., then the samples must be kept refrigerated. Minimize exposure of samples to fluorescence light. All samples should be extracted within one week after sampling.

12.2 Soxhlet Extraction and Concentration

12.2.1 Assemble the Soxhlet apparatus [see Figure 3(a)]. Immediately before use, charge the Soxhlet apparatus with 200 to 250 mL of methylene chloride and reflux for 2 hours. Let the apparatus cool, disassemble it, transfer the methylene chloride to a clean glass container, and retain it as a blank for later analysis, if required. Place the adsorbent and filter together in the Soxhlet apparatus (the use of an extraction thimble is optional) if using XAD-2 adsorbent in the sampling module. [Note: The filter and adsorbent are analyzed together in order to reach detection limits, avoid questionable interpretation of the data, and minimize cost.] Since methylene chloride is not a suitable solvent for PUF, 10% ether in hexane is employed to extract the PAHs from the PUF resin bed separate from the methylene chloride extraction of the accompanying filter rather than methylene chloride for the extraction of the XAD-2 cartridge.

12.2.1.1 Prior to extraction, add a surrogate standard to the Soxhlet solvent. A surrogate standard (i.e., a chemically inert compound not expected to

occur in an environmental sample) should be added to each sample, blank, and matrix spike sample just prior to extraction or processing. The recovery of the surrogate standard is used to monitor for unusual matrix effects, gross sample processing errors, etc. Surrogate recovery is evaluated for acceptance by determining whether the measured concentration falls within the acceptance limits. The following surrogate standards have been successfully utilized in determining matrix effects, sample process errors, etc. utilizing GC/FID, GC/MS or HPLC analysis.

Surrogate Standard	Concentration	Analytical Technique
Dibromobiphenyl	50 ng/uL	GC/FID
Dibromobiphenyl	50 ng/uL	GC/MS
Deuterated Standards	50 ng/uL	GC/MS
Decafluorobiphenyl	50 ng/uL	HPLC

[Note: The deuterated standards will be added in Section 14.3.2. Deuterated analogs of selective PAHs cannot be used as surrogates for HPLC analysis due to coelution problems.] Add the surrogate standard to the Soxhlet solvent.

12.2.1.2 For the XAD-2 and filter extracted together, add 300 mL of methylene chlorine to the apparatus and reflux for 18 hours at a rate of at least 3 cycles per hour.

12.2.1.3 For the PUF extraction separate from the filter, add 300 mL of 10 percent ether in hexane to the apparatus and reflux for 18 hours at a rate of at least 3 cycles per hour.

12.2.1.4 For the filter extraction, add 300 mL of methylene chloride to the apparatus and reflux for 18 hours at a rate of at least 3 cycles per hour.

12.2.2 Dry the extract from the Soxhlet extraction by passing it through a drying column containing about 10 grams of anhydrous sodium sulfate. Collect the dried extract in a Kuderna-Danish (K-D) concentrator assembly. Wash the

12.4.2.2 The column is cleaned and activated according to the following cleanup sequence:

Fraction	Solvent Composition	Volume (mL)
1	100% Hexane	20
2	80% Hexane/20% Methylene Chloride	10
3	50% Hexane/50% Methylene Chloride	10
4	100% Methylene Chloride	10
5	95% Methylene Chloride/5% Methanol	10
6	80% Methylene Chloride/20% Methanol	10

12.4.2.3 Reverse the sequence at the end of the run and run to the 100% hexane fraction in order to activate the column. Discard all fractions.

12.4.2.4 Pre-elute the column with 40 mL of hexane, which is also discharged.

12.4.2.5 Inject 1 mL of the cyclohexane sample extract, followed by 1 mL injection of blank cyclohexane.

12.4.2.6 Continue elution of the column with 20 mL of hexane, which is also discharged.

12.4.2.7 Now elute the column with 180 mL of a 40/60 mixture of methylene chloride/hexane respectively.

12.4.2.8 Collect approximately 180 mL of the 40/60 methylene chloride/hexane mixture in a K-D concentrator assembly.

12.4.2.9 Concentrate to less than 10 mL with the K-D assembly as discussed in Section 12.2.

12.4.2.10 The extract is now ready for either HPLC or GC analysis.

13. Gas Chromatography Analysis with Flame Ionization Detection

13.1 Gas chromatography (GC) is a quantitative analytical technique useful for PAH identification. This method provides the user the flexibility of column selection (packed or capillary) and detector [flame ionization (FI) or mass spectrometer (MS)] selection. The mass spectrometer provides for specific identification of B(a)P; however, with system optimization, other PAHs may be qualitatively and quantitatively detected using MS (see Section 14.0). This procedure provides for common GC separation of the PAHs with

extractor flask and sodium sulfate column with 100 - 125 mL of methylene chloride to complete the quantitative transfer.

12.2.3 Assemble a Kuderna-Danish concentrator [see Figure 3(b)] by attaching a 10 mL concentrator tube to a 500 mL evaporative flask. [Note: Other concentration devices (vortex evaporator) or techniques may be used in place of the K-D as long as qualitative and quantitative recovery can be demonstrated.]

12.2.4 Add two boiling chips, attach a three-ball macro-Snyder column to the K-D flask, and concentrate the extract using a water bath at 60 to 65°C. Place the K-D apparatus in the water bath so that the concentrator tube is about half immersed in the water and the entire rounded surface of the flask is bathed with water vapor. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in one hour. At the proper rate of distillation, the balls of the column actively chatter but the chambers do not flood. When the liquid has reached an approximate volume of 5 mL, remove the K-D apparatus from the water bath and allow the solvent to drain for at least 5 minutes while cooling.

12.2.5 Remove the Snyder column and rinse the flask and its lower joint into the concentrator tube with 5 mL of cyclohexane.

12.3 Solvent Exchange

12.3.1 Replace the K-D apparatus equipped with a Snyder column back on the water bath.

12.3.2 Increase the temperature of the hot water bath to 95-100°C. Momentarily, remove the Snyder column, add a new boiling chip, and attach a two-ball micro-Snyder column. Prewet the Snyder column, using 1 mL of cyclohexane. Place the K-D apparatus on the water bath so that the concentrator tube is partially immersed in the hot water. Adjust the vertical position of the apparatus and the water temperature, as required, to complete concentration in 15-20 minutes. At the proper rate of distillation, the balls of the column will actively chatter, but the chambers

will not flood. When the apparent volume of liquid reaches 0.5 mL, remove the K-D apparatus and allow it to drain and cool for at least 10 minutes.

12.3.3 When the apparatus is cool, remove the micro-Snyder column and rinse its lower joint into the concentrator tube with about 0.2 mL of cyclohexane. [Note: A 5 mL syringe is recommended for this operation]. Adjust the extract volume to exactly 1.0 mL with cyclohexane. Stopper the concentrator tube and store refrigerated at 4°C, if further processing will not be performed immediately. If the extract will be stored longer than 24 hours, it should be transferred to a Teflon®-sealed screw-cap vial.

12.4 Sample Cleanup By Solid Phase Exchange

Cleanup procedures may not be needed for relatively clean matrix samples. If the extract in Section 12.3.3 is clear, cleanup may not be necessary. If cleanup is not necessary, the cyclohexane extract (1 mL) can be analyzed directly by GC/FI detection, except the initial oven temperature begins at 30°C rather than 80°C for cleanup samples (see Section 13.3), or solvent exchange to acetonitrile for HPLC analysis. If cleanup is required, the procedures are presented using either handpack silica gel column as prescribed in Method 610 (see Section 18.0, citation No. 18 and 22) or the use of a Lobar prepacked silica gel column for PAH concentration and separation. Either approach can be employed by the user.

12.4.1 Method 610 Cleanup Procedure [see Figure 3(c)]

12.4.1.1 Pack a 6-inch disposable Pasture pipette (10 mm I.D. x 7 cm length) with a piece of glass wool. Push the wool to the neck of the disposable pipette. Add 10 grams of activated silica gel in methylene chloride slurry to the disposable pipette. Gently tap the column to settle the silica gel and elute the methylene chloride. Add 1 gram of anhydrous sodium sulfate to the top of the silica gel column.

12.4.1.2 Prior to initial use, rinse the column with methylene chloride at 1 mL/min for 1 hr to

subsequent detection by either FI or MS (see Figure 12.0). The following PAHs have been quantified by GC separation with either FI or MS detection:

Acenaphthene	Chrysene
Acenaphthylene	Dibenzo(a,h)anthracene
Anthracene	Fluoranthene
Benzo(a)anthracene	Fluorene
Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene
Benzo(b)fluoranthene	Naphthalene
Benzo(e)pyrene	Phenanthrene
Benzo(g,h,i)perylene	Pyrene
Benzo(k)fluoranthene	

The packed column gas chromatographic method described here can not adequately resolve the following four pairs of compounds: anthracene and phenanthrene; chrysene and benzo(a)anthracene; benzo(b)fluoranthene and benzo(k)fluoranthene; and dibenzo(a,h) anthracene and indeno(1,2,3-cd)pyrene. The use of a capillary column instead of the packed column, also described in this method, should adequately resolve these PAHs. However, unless the purpose of the analysis can be served by reporting a quantitative sum for an unresolved PAH pair, either capillary gas chromatography/mass spectroscopy (Section 14.0) or high performance liquid chromatography (Section 15.0) should be used for these compounds. This section will address the use of GC/FI detection using packed or capillary columns.

13.2 To achieve maximum sensitivity with the GC/FI method, the extract must be concentrated to 1.0 mL, if not already concentrated to 1 mL. If not already concentrated to 1 mL, add a clean boiling chip to the methylene chloride extract in the concentrator tube. Attach a two-ball micro-Snyder column. Prewet the micro-Snyder column by adding about 2.0 mL of methylene chloride to the top. Place the micro K-D apparatus on a hot water bath (60 to 65°C) so that the concentrator tube is partially immersed in the hot water. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 5 to 10 minutes. At the proper rate of distillation the balls will actively chatter but the chambers will not flood. When the apparent volume of liquid reaches 0.5 mL, remove the K-D apparatus. Drain and cool for at least 10 minutes. Remove the micro-Snyder column and rinse its lower joint into the concentrator tube with a small volume of methylene chloride. Adjust the final volume to 1.0 mL and stopper the concentrator tube.

13.3 Assemble and establish the following operating parameters for the GC equipped with an FI detector:

	Capillary (A)	Capillary (B)	Packed
Identification	SPB-5 fused silica capillary, 0.25 um 5% phenyl, methyl siloxane bonded	SPB-5 fused silica capillary, 0.25 um 5% phenyl, methyl siloxane bonded	Chromosorb W-AW-DMCS (100/120 mesh) coated with 3% OV-17
Dimensions	30-m x 0.25-mm ID	30-m x 0.25-mm ID	1.8-m x 2-mm ID
Carrier Gas	Helium	Helium	Nitrogen
Carrier Gas Flow Rate	28-30 cm/sec (1 cm/minute)	28-30 cm/sec (1 cm/minute)	30-40 cm/minute
Column Program	35°C for 2 min; program at 8°C/min to 280°C and hold for 12 minutes	80°C for 2 min; program at 8°C/min to 280°C and hold for 12 minutes	Hold at 100°C for 4 minutes; program at 8°C/min to 280°C and hold for 15 minutes
Detector	Flame Ionization	Flame Ionization	Flame Ionization

(A) Without column cleanup (see Section 12.4)
(B) With column cleanup (see Section 12.4.1)

13.4 Prepare and calibrate the chromatographic system using either the external standard technique (Section 13.4.1) or the internal standard technique (Section 13.4.2). Figure 13.0 outlines the following sequence involving GC calibration and retention time window determination.

13.4.1 External Standard Calibration Procedure - For each analyte of interest, including surrogate compounds for spiking, if used, prepare calibration standards at a minimum of five concentration levels by adding volumes of one or more stock standards to a volumetric flask and diluting to volume with methylene chloride. [Note: All calibration standards of interest involving selected PAHs, of the same concentration, can be prepared in the same flask.]

13.4.1.1 Prepare stock standard solutions at a concentration of 100 ug/uL by dissolving 0.100 gram of assayed PAH material in methylene chloride and diluting to vol- in a 10 mL volumetric flask. [Note: Larger volumes can be used at the convenience of the analyst.]

13.4.1.2 When compound purity is assayed to be 98% or greater, the weight can be used without correction to calculate the concentration of the stock standard. [Note: Commercially prepared stock standards can be used at any concentration if they are certified by the manufacturer or by an independent source.] Transfer the stock standard solutions into Teflon®-sealed screw-cap bottles.

13.4.1.3 Store at 4°C and protect from light. Stock standards should be checked frequently for signs of degradation or evaporation, especially just prior to preparing calibration standards from them. Stock standard solutions must be replaced after one year, or sooner, if comparison with check standards indicates a problem.

13.4.1.4 Calibration standards at a minimum of five concentration levels should be prepared through dilution of the stock standards with methylene chloride. One of the concentration levels should be at a concentration near, but above, the method detection limit. The remaining concentration levels should correspond to the expected range of concentrations found in real samples or should define the working range of the GC. [Note: Calibration solutions must be replaced after six months, or sooner, if comparison with a check standard indicates a problem.]

13.4.1.5 Inject each calibration standard using the technique that will be used to introduce the actual samples into the gas chromatograph (e.g., 1- to 3-uL injections). [Note: The same amount must be injected each time.]

13.4.1.6 Tabulate peak height or area responses against the mass injected. The results can be used to prepare a calibration curve for each analyte. [Note: Alternatively, for samples that are introduced into the gas chromatograph using a syringe, the ratio of the response to the amount

injected, defined as the calibration factor (CF), can be calculated for each analyte at each standard concentration by the following equation:

$$\text{Calibration factor (CF)} = \frac{\text{Total Area of Peak}}{\text{Mass injected (in nanograms)}}$$

If the percent relative standard deviation (%RSD) of the calibration factor is less than 20% over the working range, linearity through the origin can be assumed, and the average calibration factor can be used in place of a calibration curve.]

13.4.1.7 The working calibration curve or calibration factor must be verified on each working day by the injection of one or more calibration standards. If the response for any analyte varies from the predicted response by more than ±20%, a new calibration curve must be prepared for that analyte. Calculate the percent variance by the following equation:

$$\text{Percent variance} = \frac{R_2 - R_1}{R_1} \times 100$$

where

R_2 = Calibration factor from succeeding analysis.

R_1 = Calibration factor from first analysis.

13.4.2 Internal Standard Calibration Procedure - To use this approach, the analyst must select one or more internal standards that are similar in analytical behavior to the compounds of interest. The analyst must further demonstrate that the measurement of the internal standard is not affected by method or matrix interferences. Due to these limitations, no internal standard applicable to all samples can be suggested. [Note: It is recommended that the internal standard approach be used only when the GC/MS procedure is employed due to coeluting species.]

13.4.2.1 Prepare calibration standards at a minimum of five concentration levels for each analyte of interest by adding volumes of one or more stock standards to a volumetric flask.

13.4.2.2 To each calibration standard, add a known constant amount of one or more internal standard and dilute to volume with methylene chloride. [Note: One of the standards should be at a concentration near, but above, the method detection limit. The other concentrations should correspond to the expected range of concentrations found in real samples or should define the working range of the detector.]

13.4.2.3 Inject each calibration standard using the same introduction technique that will be applied to the actual samples (e.g., 1- to 3-uL injection).

13.4.2.4 Tabulate the peak height or area responses against the concentration of each compound and internal standard.

13.4.2.5 Calculate response factors (RF) for each compound as follows:

$$\text{Response Factor (RF)} = (A_s C_{is})/(A_{is} C_s)$$

where:

A_s = Response for the analyte to be measured (area units or peak height).

A_{is} = Response for the internal standard. (area units or peak height).

C_{is} = Concentration of the internal standard, (ug/L).

C_s = Concentration of the analyte to be measured, (ug/L).

13.4.2.6 If the RF value over the working range is constant (<20% RSD), the RF can be assumed to be invariant, and the average RF can be used for calculations. [Note: Alternatively, the results can be used to plot a calibration curve of response ratios, A_s/A_{is} versus RF.]

13.4.2.7 The working calibration curve or RF must be verified on each working day by the measurement of one or more calibration standards.

13.4.2.8 If the response for any analyte varies from the predicted response by more than ±20%, a new calibration curve must be prepared for that compound.

13.5 Retention Time Windows Determination

13.5.1 Before analysis can be performed, the retention time windows must be established for each analyte.

13.5.2 Make sure the GC system is within optimum operating conditions.

13.5.3 Make three injections of the standard containing all compounds for retention time window determination. [Note: The retention time window must be established for each analyte throughout the course of a 72-hr period.]

13.5.4 The retention window is defined as plus or minus three times the standard deviation of the absolute retention times for each standard.

13.5.5 Calculate the standard deviation of the three absolute retention times for each single component standard. In those cases where the standard deviation for a particular standard is zero, the laboratory must substitute the standard deviation of a close eluting, similar compound to develop a valid retention time window.

13.5.6 The laboratory must calculate retention time windows for each standard on each GC column and whenever a new GC column is installed. The data must be noted and retained in a notebook by the laboratory as part of the user SOP and as a quality assurance check of the analytical system.

13.6 Sample Analysis

13.6.1 Inject 1- to 3-uL of the methylene chloride extract from Section 13.2 (however, the same amount each time) using the splitless injection technique when using capillary column. [Note: Smaller (1.0 uL) volumes can be injected if automatic devices are employed.]

13.6.2 Record the volume injected and the resulting peak size in area units or peak height.

13.6.3 Using either the internal or external calibration procedure, determine the identity and quantity of each component peak in the sample chromatogram through retention time window and established calibration curve. Table 2 outlines typical retention times for selected PAHs, using both the packed and capillary column technique coupled with FI detection, while Figure 14.0 illustrates typical chromatogram for a packed column analysis.

13.6.3.1 If the responses exceed the linear range of the system, dilute the extract and reanalyze. It is recommended that extracts be diluted so that all peaks are on scale. Overlapping peaks are not always evident when peaks are off scale. Computer reproduction of chromatograms, manipulated to ensure all peaks are on scale over a 100-fold range, are acceptable if linearity is demonstrated. Peak height measurements are recommended over peak area integration when overlapping peaks cause errors in area integration.

13.6.3.2 Establish <u>daily</u> retention time windows for each analyte. Use the absolute retention time for each analyte from Section 13.5.4 as the midpoint of the window for that day. The daily retention time window equals the midpoint $\pm$ three times the standard deviation determined in Section 13.5.4.

13.6.3.3 Tentative identification of an analyte occurs when a peak from a sample extract falls within the daily retention time window. [Note: Confirmation may be required on a second GC column, or by GC/MS (if concentration permits) or by other recognized confirmation techniques if overlap of peaks occur.]

13.6.3.4 Validation of GC system qualitative performance is performed through the use of the midlevel standards. If the mid-level standard falls outside its daily retention time window, the system

is out of control. Determine the cause of the problem and perform a new calibration sequence (see Section 13.4).

13.6.3.5 Additional validation of the GC system performance is determined by the surrogate standard recovery. If the recovery of the surrogate standard deviates from 100% by not more than 20%, then the sample extraction, concentration, clean-up and analysis is certified. If it exceeds this value, then determine the cause of the problem and correct.

13.6.4 Determine the concentration of each analyte in the sample according to Sections 17.1 and 17.2.1.

14. Gas Chromatography with Mass Spectroscopy Detection

14.1 The analysis of the extracted sample for benzo[a]pyrene and other PAHs is accomplished by an electron impact gas chromatography/mass spectrometry (EI GC/MS) in the selected ion monitoring (SIM) mode with a total cycle time (including voltage reset time) of one second or less. The GC is equipped with an ultra No. 2 fused silica capillary column (50-m x 0.25-mm I.D.) with helium carrier gas for analyte separation. The GC column is temperature controlled and interfaced directly to the MS ion source.

14.2 The laboratory must document that the EI GC/MS system is properly maintained through periodic calibration checks. The GC/MS system should have the following specifications:

Mass range: 35-500 amu
Scan time: 1 sec/scan
GC Column: 50 m x 0.25 mm I.D. (0.25 um film thickness)
Ultra No. 2 fused silica capillary column or equivalent
Initial column temperature and hold time: 40°C for 4 min
Column temperature program: 40-270°C at 10°C/min
Final column temperature hold: 270°C (until benzo[g,h,i] perylene has eluted)
Injector temperature: 250-300°C
Transfer line temperature: 250-300°C
Source temperature: According to manufacturer's specifications
Injector: Grob-type, splitless
EI Condition: 70 eV
Mass Scan: Follow manufacturer instruction for select ion monitoring (SIM) mode.
Sample volume: 1-3 uL
Carrier gas: Helium at 30 cm/sec.

The GC/MS is tuned using a 50 ng/uL solution of decafluorotriphenylphosphine (DFTPP). The DFTPP permits the user to tune the mass spectrometer on a daily basis. If properly tuned, the DFTPP key ions and ion abundance criteria should be met as outlined in Table 3.

14.3 The GC/MS operating conditions are outlined in Table 4. The GC/MS system can be calibrated using the external standard technique (Section 14.3.1) or the internal standard technique (Section 14.3.2). Figure 15.0 outlines the following sequence involving the GC/MS calibration.

14.3.1 External standard calibration procedure.

14.3.1.1 Prepare calibration standard of B[a]P or other PAHs at a minimum of five concentration levels by adding volumes of one or more stock standards to a volumetric flask and diluting to volume with methylene chloride. The stock standard solution of B[a]P (1.0 ug/uL) must be prepared from pure standard materials or purchased as certified solutions.

14.3.1.2 Place 0.0100 grams of native B[a]P or other PAHs on a tared aluminum weighing disk and weigh on a Mettler balance.

14.3.1.3 Quantitatively, transfer to a 10 ml volumetric flask. Rinse the weighing disk with several small portions of methylene chloride. Ensure all material has been transferred.

14.3.1.4 Dilute to mark with methylene chloride.

14.3.1.5 The concentration of the stock standard solution of B[a]P or other PAHs in the flask is 1.0 ug/uL [Note: Commerically prepared stock standards may be used at any concentration if they are certified by the manufacturer or by an independent source.]

14.3.1.6 Transfer the stock standard solutions into Teflon®-sealed screw-cap bottles. Store at 4°C and protect from light. Stock standard solutions should be checked frequently for signs of degradation or evaporation, especially just prior to preparing calibration standards from them.

14.3.1.7 Stock standard solutions must be replaced after 1 yr or sooner if comparison with quality control check samples indicates a problem.

14.3.1.8 Calibration standards at a minimum of five concentration levels should be prepared. [Note: One of the calibration standards should be at a concentration near, but above the method detection limit; the others should correspond to the range of concenrations found in the sample but should not exceed the working range of the GC/MS system.] Accurately pipette 1.0 ml of the stock solution (1 ug/uL) into another 10 mL volumetric flask, dilute to mark with methylene chloride. This daughter solution contains 0.1 ug/uL of B[a]P or other PAHs.

14.3.1.9 Prepare a set of standard solutions by appropriately diluting, with methylene chloride, accurately measured volumes of the daughter solution (0.1 ug/uL).

14.3.1.10 Accurately pipette 100 uL, 300 uL, 500 uL, 700 uL and 1000 uL of the daughter solution (0.1 ug/uL) into each 10 mL volumetric flask, respectively. To each of these flasks, add an internal deuterated standard to give a final concentration of 40 ng/uL of the internal deuterated standard (Section 14.3.2.1). Dilute to mark with methylene chloride.

14.3.1.11 The concentration of B[a]P in each flask is 1 ng/uL, 3 ng/uL, 5 ng/uL, 7 ng/uL, and 10 ug/uL respectively. All standards should be stored at 4°C and protected from fluorescent light and should be freshly prepared once a week or sooner if check standards indicates a problem.

14.3.1.12 Analyze a constant volume (1-3 uL) of each calibration standard and tabulate the area responses of the primary characteristic ion of each standard against the mass injected. The results may be used to prepare a calibration curve for each compound. Alternatively, if the ratio of response

to amount injected (calibration factor) is a constant over the working range (<20% relative standard deviation, RSD), linearity through the origin may be assumed and the average ratio or calibration factor may be used in place of a calibration curve.

14.3.1.13 The working calibration curve or calibration factor must be verified on each working day by the measurement of one or more calibration standards. If the response for any parameter varies from the predicted response by more than ± 20%, the test must be repeated using a fresh calibration standard. Alternatively, a new calibration curve or calibration factor must be prepared for that compound.

14.3.2 Internal standard calibration procedure.

14.3.2.1 To use this approach, the analyst must select one or more internal standards that are similar in analytical behavior to the compounds of interest. For analysis of B[a]P, the analyst should use perylene -d_{12}. The analyst must further demonstrate that the measurement of the internal standard is not affected by method or matrix interferences. The following internal standards are suggested at a concentration of 40 ng/uL for specific PAHs:

Perylene - d_{12}	Acenaphthene - d_{10}
Benzo(a)pyrene	Acenaphthene
Benzo(k)fluoranthene	Acenaphthylene
Benzo(g,h,i)perylene	Fluorene
Dibenzo(a,h)anthracene	
Indeno(1,2,3-cd)pyrene	Naphthalene - d_8
Chrysene - d_{12}	Naphthalene
Benzo(a)anthracene	Phenanthrene -d_{10}
Chrysene	
Pyrene	Anthracene
	Fluoranthene
	Phenanthrene

14.3.2.2 A mixture of the above deuterated compounds in the appropriate concentration range are commercially available (see Section 9.3.1.5).

14.3.2.3 Use the base peak ion as the primary ion for quantification of the standards. If interferences are noted, use the next two most intense ions as the secondary ions. The internal standard is added to all calibration standards and all sample extracts analyzed by GC/MS. Retention time standards, column performance standards, and a mass spectrometer tuning standard may be included in the internal standard solution used.

14.3.2.4 Prepare calibration standards at a minimum of three concentration level for each parameter of interest by adding appropriate volumes of one or more stock standards to a volumetric flask. To each calibration standard or standard mixture, add a known constant amount of one or more of the internal deuterated standards to yield a resulting concentration of 40 ng/uL of internal standard and dilute to volume with methylene chloride. One of the calibration standards should be at a concentration near, but above, the minimum detection limit (MDL) and the other concentrations should correspond to the expected range of concentrations found in real samples or should define the working range of the GC/MS system.

14.3.2.5 Analyze constant amount (1-3 uL) of each calibration standard and tabulate the area of the primary characteristic ion against concentration for each compound and internal standard, and calculate the response factor (RF) for each analyte using the following equation:

$$RF = (A_s C_{is})/(A_{is} C_s)$$

Where:

A_s = Area of the characteristic ion for the analyte to be measured.

A_{is} = Area of the characteristic ion for the internal standard.

C_{is} = Concentration of the internal standard, (ng/uL).

C_s = Concentration of the analyte to be measured, (ng/uL).

If the RF value over the working range is a constant (<20% RSD), the RF can be assumed to be invariant and the average RF can be used for calculations. Alternatively, the results can be used to plot a calibration curve of response ratios, A_s/A_{is}, vs. RF. Table 5.0 outlines key ions for selected internal deuterated standards.

14.3.2.6 The working calibration curve or RF must be verified on each working day by the measurement of one or more calibration standards. If the response for any parameter varies from the predicted response by more than ± 20%, the test must be repeated using a fresh calibration standard. Alternatively, a new calibration curve must be prepared.

14.3.2.7 The relative retention times for each compound in each calibration run should agree within 0.06 relative retention time units.

14.4 Sample Analysis

14.4.1 It is highly recommended that the extract be screened on a GC/FID or GC/PID using the same type of capillary column as in the GC/MS procedure. This will minimize contamination of the GC/MS system from unexpectedly high concentrations of organic compounds.

14.4.2 Analyze the 1 mL extract (see Section 13.2) by GC/MS. The recommended GC/MS operating conditions to be used are specified in Section 14.2.

14.4.3 If the response for any quantitation ion exceeds the initial calibration curve range of the GC/MS system, extract dilution must take place. Additional internal standard must be added to the diluted extract to maintain the required 40 ng/uL of each internal standard in the extracted volume. The diluted extract must be reanalyzed.

14.4.4 Perform all qualitative and quantitative measurements as described in Section 14.3. The typical characteristic ions for selective PAHs are outlined in Table 6.0. Store the extracts at 4°C, protected from light in screw-cap vials equipped with unpierced Teflon®-lined, for future analysis.

14.4.5 For sample analysis, the comparison between the sample and references spectrum must illustrate:

(1) Relative intensities of major ions in the reference spectrum (ions >10% of the most abundant ion) should be present in the sample spectrum.

(2) The relative intensities of the major ions should agree within ±20%. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must be between 30 and 70%).

(3) Molecular ions present in the reference spectrum should be present in the sample spectrum.

(4) Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contaminatiuon or presence of coeluting compounds.

(5) Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks. Data system library reduction programs can sometimes create these discrepancies.

14.4.6 Determine the concentration of each analyte in the sample according to Sections 17.1 and 17.2.2.

14.5 GC/MS Performance Tests

14.5.1 Daily DFTPP Tuning - At the beginning of each day that analyses are to be performed, the GC/MS system must be checked to see that acceptable performance criteria are achieved when challenged with a 1 uL injection volume containing 50 ng of decafluorotriphenylphosphine (DFTPP). The DFTPP key ions and ion abundance criteria that must be met are illustrated in Table 3.0. Analysis should not begin until all those criteria are met. Background subtraction should be staightforward and designed only to eliminate column bleed or instrument background ions. The GC/MS tuning standard should also be used to assess GC column performance and injection port inertness. Obtain a background correction mass spectra of DFTPP and check that all key ions criteria are met. If the criteria are not achieved, the analyst must retune the mass spectrometer and repeat the test until all criteria are achieved. The

performance criteria must be achieved before any samples, blanks on standards are analyzed. If any key ion abundance observed for the daily DFTPP mass tuning check differs by more than 10% absolute abundance from that observed during the previous daily tuning, the instrument must be retuned or the sample and/or calibration solution reanalyzed until the above condition is met.

14.5.2 Daily 1-point Initial Calibration Check - At the beginning of each work day, a daily 1-point calibration check is performed by re-evaluating the midscale calibration standard. This is the same check that is applied during the initial calibration, but one instead of five working standards are evaluated. Analyze the one working standards under the same conditions the initial calibration curve was evaluated. Analyze 1 uL of each of the mid-scale calibration standard and tabulate the area response of the primary characteristic ion against mass injected. Calculate the percent difference using the following equation:

$$\% \text{ Difference} = \frac{RF_c - \overline{RF_I}}{\overline{RF_I}} \times 100$$

Where:

$\overline{RF_I}$ = average response factor from initial calibration using mid-scale standard.

RF_c = response factor from current verification check using mid-scale standard.

If the percent difference for the mid-scale level is greater than 10%, the laboratory should consider this a warning limit. If the percent difference for the mid-scale standard is less than 20%, the initial calibration is assumed to be valid. If the criterion is not met (<20% difference), then corrective action MUST be taken. [Note: Some possible problems are standard mixture degradation, injection port inlet contamination, contamination at the front end of the analytical column, and active sites in the column or chromatographic system.] This check must be met

before analysis begins. If no source of the problem can be determined after corrective action has been taken, a new five-point calibration MUST be generated. This criterion MUST be met before sample analysis begins.

14.5.3 12-hour Calibration Verification - A calibration standard at mid-level concentration containing B[a]P or other PAHs must be performed every twelve continuous hours of analysis. Compare the standard every 12-hours with the average response factor from the initial calibration. If the % difference for the response factor (see Section 14.5.2) is less than 20%, then the GC/MS system is operative within initial calibration values. If the criteria is not met (>20% difference), then the source of the problem must be determined and a new five-point curve MUST be generated.

14.5.4 Surrogate Recovery - Additional validation of the GC system performance is determined by the surrogate standard recovery. If the recovery of the surrogate standard deviates from 100% by not more than 20%, then the sample extraction, concentration, clean-up and analysis is certified. If it exceeds this value, then determine the cause of the problem and correct.

15. High Performance Liquid Chromatography (HPLC) Detection

15.1 Introduction

15.1.1 Detection of B[a]P by HPLC has also been a viable tool in recent years. The procedure outlined below has been written specifically for analysis of B[a]P by HPLC. However, by optimizing chromatographic conditions [(multiple detector fluorescence - excitation at 240 nm, emission at 425 nm; ultraviolet at 254 nm)] and varying the mobile phase composition through a gradient program, the following PAHs may also be quantitatified:

COMPOUND	DETECTOR[1]	COMPOUND	DETECTOR[1]
Acenaphthene	UV	Benzo(k)fluoranthene	FL
Acenaphthylene	UV	Dibenzo(a,h)anthracene	FL
Anthracene	UV	Fluoranthene	FL
Benzo(a)anthracene	FL	Fluorene	UV
Benzo(a)pyrene	FL	Indeno(1,2,3-cd)pyrene	FL
Benzo(b)fluoranthene	FL	Naphthalene	UV
Benzo[e]pyrene	FL	Phenanthrene	UV
Benzo(ghi)perylene	FL	Pyrene	FL

[1]UV= Ultraviolet
FL= Fluorescences

15.1.2 This method provides quantitative identification of the selected PAH's compounds listed above by high performance liquid chromatography. It is based on separating of compounds of a liquid mixture through a liquid chromatographic column and measuring the separated components with suitable detectors.

15.1.3 The method involves solvent exchange, with subsequent HPLC detection involving ultraviolet (UV) and fluoresence (FL) detection.

15.2 Solvent Exchange To Acetonitrile

15.2.1 To the extract in the concentrator tube, add 4 mL of acetonitrile and a new boiling chip; attach a micro-snyder column to the apparatus.

15.2.2 Increase temperature of the hot water bath to 95 to 100°C.

15.2.3 Concentrate the solvent as in Section 12.3.

15.2.4 After cooling, remove the micro-Snyder column and rinse its lower sections into the concentration tube with approximately 0.2 mL acetonitrile.

15.2.5 Adjust its volume to 1.0 mL.

15.3 HPLC Assembly

15.3.1 The HPLC system is assembled, as illustrated in Figure 10.

15.3.2 The HPLC system is operated according to the following parameters:

HPLC Operating Parameters

Guard Column:	VYDAC 201 GCCIOYT	
Analytical Column:	VYDAC 201 TP5415 C-18 RP (0.46 x 25 cm)	
Column Temperature:	27.0 ± 2°C	
Mobile Phase:	Solvent Composition	Time (Minutes)
	40% Acetonitrile/60% water	0
	100% Acetonitrile	25
	100% Acetonitrile	35
	40% Acetonitrile/60% water	45
	Linear gradient elution at 1.0 mL/min	
Detector:	Variable wavelength ultraviolet and fluorescence.	
Flow Rate:	1.0 mL/minute	

[Note: To prevent irreversible absorption due to "dirty" injections and premature loss of column efficiency, a guard column is installed between the injector and the analytical column. The guard column is generally packed with identical material as is found in the analytical column. The guard column is generally replaced with a fresh guard column after several injections (50) or when separation between compounds becomes difficult. The analytical column specified in this procedure has been laboratory evaluated. Other analytical columns may be used as long as they meet procedure and separation requirements. Table 7.0 outlines other columns uses to determine PAHs by HPLC.]

15.3.3 The mobile phases are placed in separate HPLC solvent reservoirs and the pumps are set to yield a total of 1.0 mL/minute and allowed to pump for 20-30 minutes before the first analysis. The detectors are switched on at least 30 minutes before the first analysis. UV detection at 254 nm is generally preferred. The fluorescence spectrometer excitation wavelengths range from 250 to 800 nanometers. The excitation and emission slits are both set at 10 nanometers nominal bandpass.

15.3.4 Before each analysis, the detector baseline is checked to ensure stable operation.

15.4 HPLC Calibration

15.4.1 Prepare stock standard solutions at PAH concentrations of 1.00 ug/uL by dissolving 0.0100 grams of assayed material in acetonitrile and diluting to volume in a 10 mL volumetric flask. [Note: Larger volumes can be used at the convenience of the analyst. When compound purity is assayed to be 98% or greater, the weight can be used without correction to calculate the concentration of the stock standard.] Commercially prepared stock standards can be used at any concentration if they are certified by the manufacturer or by an independent source.

15.4.2 Transfer the stock standard solutions into Teflon®-sealed screw-cap bottles. Store at 4°C and protect from light. Stock standards should be checked frequently for signs of degradation or evaporation, especially just prior to preparing calibration standards from them.

15.4.3 Stock standard solutions must be replaced after one year, or sooner, if comparision with check standards indicates a problem.

15.4.4 Prepare calibration standards at a minimum of five concentration levels ranging from 1 ng/uL to 10 ng/uL by first diluting the stock standard 10:1 with acetonitrile, giving a daughter solution of 0.1 ug/uL. Accurately pipette 100 uL, 300 uL, 500 uL, 700 uL and 1000 uL of the daughter solution (0.1 ug/uL) into each 10 mL volumetric flask, respectively. Dilute to mark with acetonitrile. One of the concentration levels should be at a concentration near, but above, the method detection limit (MDL). The remaining concentration levels should correspond to the expected range of concentrations found in real samples or should define the working range of the HPLC. [Note: Calibration standards must be replaced after six months, or sooner, if comparison with check standards indicates a problem.]

15.4.5 Analyze each calibration standard (at lease five levels) three times. Tabulate area response vs. mass injected. All calibration runs are performed as described for sample analysis in Section 15.5.1. Typical retetion times for specific PAHs are illustrated in Table 8.0. Linear response is indicated where a correlation coefficient of at least 0.999 for a linear least-squares fit of the data (concentration versus area response) is obtained. The retention times for each analyte should agree within ± 2%.

15.4.6 Once linear response has been documented, an intermediate concentration standard near the anticipated levels for each component, but at least 10 times the detection limit, should be chosen for a daily calibration check. The response for the various components should be within 15% day to day. If greater variability is observed, recalibration may be required or a new calibration curve must be developed from fresh standards.

15.4.7 The response for each component in the daily calibration standard is used to calculate a response factor according to the following equation:

$$RF_C = \frac{C_c \times V_I}{R_C}$$

Where

RF_C = response factor (usually area counts) for the component of interest in nanograms injected/ response unit.

C_C = concentration (mg/L) of analyte in the daily calibration standard.

V_I = volume (uL) of calibration standard injected.

R_C = response (area counts) for analyte in the calibration standard.

15.5 Sample Analysis

15.5.1 A 100 uL aliquot of the sample is drawn into a clean HPLC injection syringe. The sample injection loop (10 uL) is loaded and an injection is made. The data system, if avaible, is activated simultaneously with the injection and the point of injection is marked on the strip-chart recorded.

15.5.2 After approximately one minute, the injection valve is returned to the "load" position and the syringe and valve are flushed with water in preparation for the next sample analysis.

15.5.3 After elution of the last component of interest, concentrations are calculated as described in Section 16.2.3. [Note: Table 8.0 illustrates typical retention times associates with individual PAHs, while Figure 17 represent a typical chromatogram associates with fluorescence detection.]

15.5.4 After the last compound of interest has eluted, establish a stable baseline; the system can be now used for further sample analyses as described above.

15.5.5 If the concentration of analyte exceeds the linear range of the instrument, the sample should be diluted with mobile phase, or a smaller volume can be injected into the HPLC.

15.5.6 Calculate surrogate standard recovery on all samples, blanks and spikes. Calculate the percent difference by the following equation:

$$\% \text{ difference} = \frac{S_R - S_I}{S_I} \times 100$$

Where

S_I = surrogate injected, ng.
S_R = surrogate recovered, ng.

15.5.7 Once a minimum of thirty samples of the same matrix have been analyzed, calculte the averge percent recovery (%R) and standard deviation of the percent recovery (SD) for the surrogate.

15.5.8 For a given matrix, calculate the upper and lower control limit for method performance for the surrogate standard. This should be done as follows:

Upper Control Limit (UCL) = (%R) + 3(SD)

Lower Control Limit (LCL) = (%R) - 3(SD)

The surrogate recovery must fall within the control limits. If recovery is not within limits, the following is required.

- Check to be sure there are no errors in calculations surrogate solutions and internal standards. Also, check instrument performance.
- Recalculate the data and/or reanalyze the extract if any of the above checks reveal a problem.
- Reextract and reanalyze the sample if none of the above are a problem or flag the data as "estimated concentration."

15.5.9 Determine the concentration of each analyte in the sample according to Sections 17.1 and 17.2.3.

15.6 HPLC System Performance

15.6.1 The general appearance of the HPLC system should be similar to that illustrated in Figure 10.

15.6.2 HPLC system efficiency is calculated according to the following equation:

$$N = 5.54 \quad \frac{t^2}{W_{1/2}}$$

where:

N = column efficiency (theoretical plates).

t_r = retention time (seconds) of analyte.

$W_{1/2}$ = width of component peak at half height (seconds).

A column efficiency of >5,000 theoretical plates should be obtained.

15.6.3 Precision of response for replicate HPLC injections should be ±10% or less, day to day, for analyte calibration standards at 1 ug/mL or greater levels. At 0.5 ug/mL level and below, precision of replicate analyses could vary up to 25%. Precision of retention times should be ±2% on a given day.

15.6.4 From the calibration standards, area responses for each PAH compound can be used against the concentrations to establish working calibration curves. The calibration curve must be linear and have a correlation coefficient greater than 0.98 to be acceptable.

15.6.5 The working calibration curve should be checked daily with an analysis of one or more calibration standards. If the observed response (r_p) for any PAH varies by more than 15% from the predicted response (r_p), the test method must be repeated with new calibration standards. Alternately a new calibration curve must be prepared. [Note: If $\frac{r_o - r_p}{r_p}$ >15%, recalibration is necessary.]

15.7 HPLC Method Modification

15.7.1 The HPLC procedure has been automated by Acurex Corporation as part of their "Standard Operating Procedure for Polynuclear Aromatic Hydrocarbon Analysis by High Performance Liquid Chromatography Methods," as reported in Reference 9 of Section 18.

15.7.2 The system consists of a Spectra Physics 8100 Liquid Chromatograph, a micro-processor-controlled HPLC, a ternary gradient generator, and an autosampler (10 uL injection loop).

15.7.3 The chromatographic analysis involves an automated solvent program allowing unattended instrument operation. The

solvent program consists of four timed segments using varying concentrations of acetonitrile in water with a constant flow rate, a constant column temperature, and a 10-minute equilibration time, as outlined below.

AUTOMATED HPLC WORKING PARAMETERS

Time	Solvent Composition	Temperature	Rate
10 minutes equilibration	40% Acetonitrile 60% Water	27.0 ± 2°C	1 mL/min
T=0	40% Acetonitrile 60% Water		
T=25	100% Acetonitrile		
T=35	100% Acetonitrile		
T=45	40% Acetonitrile 60% Water		

Table 9.0 outlines the associated PAHs with their minimum detection limits (MDL) which can be detected employing the automated HPLC methodology.

15.7.4 A Vydac or equivalent analytical column packed with a C_{18} bonded phase is used for PAH separation with a reverse phase guard column. The optical detection system consists of a Spectra Physics 8440 variable Ultraviolet (UV)/Visible (VIS) wavelength detector and a Perkin Elmer LS-4 Fluorescence Spectrometer. The UV/VIS detector, controlled by remote programmed commands, contains a Deuterium lamp with wavelength selection between 150 and 600 nanometers. It is set at 254 nanometers with the time constant (detector response) at 1.0 seconds.

15.7.5 The LS-4 Fluorescence Spectrometer contains separate excitation and emission monochromators which are positioned by separate microprocessor-controlled stepper motors. It contains a Xenon discharge lamp, side-on photomultiplier and a 3-microliter illuminated volume flow cell. It is equipped with a wavelength programming facility to set the monochromators automatically to a given wavelength position. This greatly enhances selectivity by changing

the fluorescence excitation and emission detection wavelengths during the chromatographic separation in order to optimize the detection of each PAH. The excitation wavelengths range from 230 to 720 nanometers; the emission wavelengths range from 250 to 800 nanometes. The excitation and emission slits are both set at 10 nanometers nominal bandpass.

15.7.6 The UV detector is used for determining naphthalene, acenaphthylene and acenapthene, and the fluorescence detector is used for the remaining PAHs. Table 9 outlines the detection techniques and minimum detection limit (MDL) employing this HPLC system. A Dual Channel Spectra Physics (SP) 4200 computing integrator, with a Labnet power supply, provides data analysis and a chromatogram. An IBM PC XT with a 10-megabyte hard disk provides data storage and reporting. Both the SP4200 and the IBM PC XT can control all functions of the instruments in the series through the Labnet system except for the LS-4, whose wavelength program is started with a signal from the High Performance Liquid Chromatograph autosampler when it injects. All data are transmitted to the XT and stored on the hard disk. Data files can later be transmitted to floppy disk storage.

16.0 Quality Assurance/Quality Control

16.1 General System QA/QC

16.1.1 Each laboratory that uses these methods is required to operate a formal quality control program. The minimum requirements of this program consist of an initial demonstration of laboratory capability and an ongoing analysis of spiked samples to evaluate and document quality data. The laboratory must maintain records to document the quality of the data generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method. When results of sample spikes indicate a typical method performance, a quality control check standard must be analyzed to confirm that the measurements were performed in an in-control mode of operation.

16.1.2 Before processing any samples, the analyst should demonstrate, through the analysis of a reagent solvent blank, that interferences from the analytical system, glassware, and reagents are under control. Each time a set of samples is extracted or there is a change in reagents, a reagent solvent blank should be processed as a safeguard against chronic laboratory contamination. The blank samples should be carried through all stages of the sample preparation and measurement steps.

16.1.3 For each analytical batch (up to 20 samples), a reagent blank, matrix spike and deuterated/surrogate samples must be analyzed (the frequency of the spikes may be different for different monitoring programs). The blank and spiked samples must be carried through all stages of the sample preparation and measurement steps.

16.1.4 The experience of the analyst performing gas chromatography and high performance liquid chromatography is invaluable to the success of the methods. Each day that analysis is performed, the daily calibration sample should be evaluated to determine if the chromatographic system is operating properly. Questions that should be asked are: Do the peaks look normal?; Is the response windows obtained comparable to the response from previous calibrations? Careful examination of the standard chromatogram can indicate whether the column is still good, the injector is leaking, the injector septum needs replacing, etc. If any changes are made to the system (e.g., column changed), recalibration of the system must take place.

16.2 Process, Field, and Solvent Blanks

16.2.1 One cartridge (XAD-2 or PUF) and filter from each batch of approximately twenty should be analyzed, without shipment to the field, for the compounds of interest per to serve as a process blank. A blank level of less than 10 ng per cartridge/filter assembly for single PAH component is considered to be acceptable.

16.2.2 During each sampling episode, at least one cartridge and filter should be shipped to the field and returned, without drawing air through the sampler, to serve as a field blank.

16.2.3 During the analysis of each batch of samples at least one solvent process blank (all steps conducted but no cartridge or filter included) should be carried through the procedure and analyzed. Blank levels should be less than 10 ng/sample for single components to be acceptable.

16.2.4 Because the sampling configuration (filter and backup adsorbent) has been tested for targeted PAHs in the laboratory in relationship to collection efficiency and has been demonstrated to be greater than 95% for targeted PAHs, no field recovery evaluation will occur as part of the QA/QC program outlined in this section.

16.3 Gas Chromatography with Flame Ionization Detection

16.3.1 Under the calibration procedures (internal and external), the % RSD of the calibration factor should be <20% over the linear working range of a five point calibration curve (Sections 13.4.1.6 and 13.4.2.6).

16.3.2 Under the calibration procedures (internal and external), the daily working calibration curve for each analyte should not vary from the predicted response by more than ±20% (Sections 13.4.1.7 and 13.4.2.8).

16.3.3 For each analyte, the retention time window must be established (Section 13.5.1), verified on a daily basis (Section 13.6.3.2) and established for each analyte throughout the course of a 72-hour period (Section 13.5.3).

16.3.4 For each analyte, the mid-level standard must fall within the retention time window on a daily basis as a qualitative performance evaluation of the GC system (Section 13.6.3.4).

16.3.5 The surrogate standard recovery must not deviate from 100% by no more than 20% (Section 13.6.3.5).

16.4 Gas Chromatography with Mass Spectroscopy Detection

16.4.1 Section 14.5.1 requires the mass spectrometer be tuned daily with DFTPP and meet relative ion abundance requirements outlined in Table 3.

16.4.2 Section 14.3.1.1 requires a minimum of five concentration levels of each analyte (plus deuterated internal standards) be prepared to establish a calibration factor to illustrate <20% variance over the linear working range of the calibration curve.

16.4.3 Section 14.3.1.13 requires the verification of the working curve each working day (if using the external standard technique) by the measurement of one or more calibration standards. The predicted response must not vary by more than ±20%.

16.4.4 Section 14.3.2.6 requires the initial calibration curve be verified each working day (if using the internal standard technique) by the measurement of one or more calibration standards. If the response varies by more than ±20% of predicted response, a fresh calibration curve (five point) must be established.

16.4.5 Section 14.4.5 requires that for sample analysis, the comparison between the sample and reference spectrum illustrate:

(1) Relative intensities of major ions in the reference spectrum (ions >10% of the most abundant ion) should be present in the sample spectrum.

(2) The relative intensities of the major ions should agree within ±20%. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must be between 30 and 70%).

(3) Molecular ions present in the reference spectrum should be present in sample the spectrum.

(4) Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contaminatiuon or presence of coeluting compounds.

(5) Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks. Data system library reduction programs can sometimes create these discrepancies.

16.4.6 Section 14.5.3 requires that initial calibration curve be verified every twelve continuous hour of analysis by a mid-level calibration standard. The response must be less than 20% difference from the initial response.

16.4.7 The surrogate standard recovery must not deviate from 100% by no more than 20% (Section 14.5.4).

16.5 High Performance Liquid Chromatography

16.5.1 Section 15.4.4 requires the preparation of calibration standards at a minimum of five concentration levels to establish correlation coefficient of at least 0.999 for a linear least-squares fit of the data.

16.5.2 Section 15.4.5 requires that the retention time for each analyte should agree within ±2%.

16.5.3 A daily calibration check involving an intermediate standard of the initial five point calibration curve should be within ±15% from day to day.

16.5.4 Section 15.5.6 requires the calculation of percent difference of surrogate standard recovery in order to establish control limits:

Upper Control Limit (UCL) = (%R) + 3 (SD)
Lower Control Limit (LCL) = (%R) - 3 (SD)

The surrogate recovery must fall within the control limits.

17. Calculations

17.1 Sample Volume

17.1.1 The total sample volume should be corrected to standard temperature and pressure.

17.1.2 The total sample volume (V_m) is calculated from the periodic flow readings (Magnehelic readings taken in Section 11.3.13) using the following equation.

$$V_m = \frac{Q_1 + Q_2 \ldots Q_n}{N} \times \frac{T}{1000}$$

Where

V_m = total sample volume (m^3) at ambient conditions .

$Q_1, Q_2 \ldots Q_n$ = flow rates determined at the beginning, end, and intermediate points during sampling (m3/minute).

N = number of data points.

T = elapsed sampling time (minutes).

17.1.3 The volume of air sampled can be converted to standard conditions (760 mm Hg pressure and 25°C) using the following equation:

$$V_s = V_m \times \frac{p_A}{760} \times \frac{298}{273 + t_A}$$

Where

V_s = total sample volume (m^3) at standard temperature and pressure (25°C and 760 mm Hg pressure).

V_m = total sample flow under ambient conditions (m^3).

p_A = ambient pressure (mm Hg).

t_A = ambient temperature (°C).

17.2 Sample Concentration

17.2.1 GC/FI Detection

17.2.1.1 The concentration of each analyte in the sample may be determined from the external standard technique by calculating the amount of standard injected, from the peak response, using the calibration curve or the calibration factor determined in Section 13.4.1.6.

17.2.1.2 The concentration of a specific analyte is calculated as follows:

$$\text{Concentration, ng/m}^3 = \frac{[(A_x)(V_t)(D)]}{[(CF)(V_i)(V_s)]}$$

Where:

CF = calibration factor for chromatographic system, peak height or area response per mass injected, Section 13.4.1.6.

A_x = Response for the analyte in the sample, area counts or peak height.

V_t = volume of total sample, uL.

D = Dilution factor, if dilution was made on the sample prior to analysis. If no dilution was made, D=1, dimensionless.

V_i = volume of sample injected, uL

V_s = total sample volume (m^3) at standard temperature and pressure (25°C and 760 mm Hg), Section 17.1.3.

17.2.2 GC/MS Detection

17.2.2.1 When an analyte has been identified, the quantification of that analyte will be based on the integrated abundance from the monitoring of the primary characteristic ion. Quantification will take place using the internal standard technique. The internal standard used shall be the one nearest the retention time of that of a given analyte (see Section 14.3.2.1).

17.2.2.2 Calculate the concentration of each identified analyte in the sample as follows:

$$\text{Concentration, ng/m}^3 = \frac{[(A_x)(I_s)(V_t)(D)]}{[(A_{is})(RF)(V_i)(V_s)]}$$

Where

A_x = area of characteristic ion(s) for analyte being measured.

I_s = amount of internal standard injected, ng.

V_t = volume of total sample, uL.

D = dilution factor, if dilution was made on the sample prior to analysis. If no dilution was made, D = 1, dimensionless.

A_{is} = area of characteristic ion(s) for internal standard.

RF = Response factor for analyte being measured, Section 14.3.2.5.

V_i = volume of analyte injected, uL.

V_s = total sample volume (m^3) at standard temperature and pressure (25°C and 760 mm Hg), Section 17.1.3.

17.2.3 HPLC Detection

17.2.3.1 The concentration of each analyte in the sample may be determined from the external standard technique by calculating response factor and peak response using the calibration curve.

17.2.3.2 The concentration of a specific analyte is calculated as follows:

$$\text{Concentration, ng/m}^3 = \frac{[(RF_c)(A_x)(V_t)(D)]}{[(V_i)(V_s)]}$$

Where

RF_c = response factor (nanograms injected per area counts) calculated in Section 15.4.7.

A_x = response for the analyte in the sample, area counts or peak height.

V_t = volume of total sample, uL.

D = dilution factor, if dilution was made on the sample prior to analysis. If no dilution was made, D = 1, dimensionless.

V_i = volume of sample injected, uL.

V_s = total sample volume (m^3) at standard temperature and pressure (25°C and 760 mm Hg), Section 17.1.3.

17.3 Sample Concentration Conversion From ng/m^3 to ppbv

17.3.1 The concentrations calculated in Section 17.2 can be converted to ppbv for general reference.

17.3.2 The analyte concentration can be converted to ppbv using the following equation:

$$C_A \text{ (ppbv)} = C_A \text{ (ng/m}^3\text{)} \times \frac{24.4}{MW_A}$$

Where

C_A = concentration of analyte, ng/m^3, calculated according to Sections 17.2.1 through 17.2.3.

MW_A = molecular weight of analyte, g/g-mole

24.4 = molar volume occupied by ideal gas at standard temperature and pressure (25°C and 760 mm Hg), l/mole.

18.0 BIBLIOGRAPHY

1. Dubois, L., Zdrojewski, A., Baker, C., and Monknao J.L., "Some Improvement in the Determination of Benzo[a]Pyrene in Air Samples," Air Pollution Control Association J., 17:818-821, 1967.
2. Intersociety Committee "Tentative Method of Analysis for Polynuclear Aromantic Hydrocarbon of Atmospheric Particulate Matter, Health Laboratory Science, Vol. 7, No. 1, pp. 31-40, January, 1970.
3. Cautreels, W., and Van Cauwenberghe, K., "Experiments on the Distribution of Organic Pollutants Between Airborne Particulate Matter and Corresponding Gas Phase", Atmos. Environ., 12:1133-1141 (1978).
4. "Tentative Method of Microanalysis for Benzo[a]Pyrene in Airborne Particules and Source Effluents," American Public Health Association, Health Laboratory Science, Vol 7, No. 1, pp. 56-59, January, 1970.
5. "Tentative Method of Chromatographic Analysis for Benzo[a]Pyrene and Benzo[k]Fluoranthene in Atmospheric Particulate Matter," American Public Health Association, Health Laboratory Science, Vol. 7, No. 1, pp. 60-67, January, 1970.
6. "Tentative Method of Spectrophotometric Analysis for Benzo[a]Pyrene in Atmospheric Particulate Matter," American Public Health Association, Health Laboratory Science, Vol. 7, No. 1, pp. 68-71, January, 1970.
7. Jones, P.W., Wilkinson, J.E., and Strup, P.E., "Measurement of Polycyclic Organic Materials and Other Hazardous Organic Compounds in Stack Gases: State-of-art," U.S. EPA-600/2-77-202, 1977.
8. "Standard Operating Procedure for Ultrasonic Extraction and Analysis of Residual Benzo[a]Pyrene from Hi-Vol Filters via Thin-Layer Chromatography", J.F. Walling, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Methods Development and Analysis Division, Research Triangle Park, N.C., EMSL/RTP-SOP-MDAD-015, December, 1986.
9. "Standard Operating Procedure for Polynuclear Aromantic Hydrocarbon Analysis by High Performance Liquid Chromatography Methods," Susan Rasor, Acurex Corporation, Research Triangle Park, N.C., 1978.
10. Rapport, S.W., Wang, Y.Y., Wei, E.T., Sawyer, R., Watkins, B.E., and Rapport, H., "Isolation and Identification of a Direct-Acting Mutagen in Diesel Exhaust Particulates", Envir. Sci. Technol., 14:1505-1509, 1980.

11. Konig, J., Balfanz, E., Funcke, W., and Romanowski, T., "Determination of Oxygenated Polycyclic Aromantic Hydorcarbons in Airborne Particulate Matter by Capillary Gas Chromatography and Gas Chromatography/Mass Spectrometry", Anal. Chem., Vol. 55, pp. 599-603, 1983.

12. Chuang, J. C., Bresler, W. E. and Hannan, S. W., "Evaluation of Polyurethane Foam Cartridges for Measurement of Polynuclear Aromantic Hydrocarbons in Air," U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Methods Development and Analysis Division, Research Triangle Park, N.C., EPA-600/4-85-055, September, 1985.

13. Chuang, J.C., Hannan, S.W., and Kogtz, J. R., "Stability of Polynuclear Aromantic Compounds Collected from Air on Quartz Fiber Filters and XAD-2 Resin," U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Methods Development and Analysis Division, Research Triangle Park, N.C., EPA-600/4-86-029, September, 1986.

14. Feng, Y. and Bidleman, T.F., "Influence of Volatility on the Collection of Polynuclear Aromantic Hydrocarbon Vapors with Polyurethane Foam", Envir. Sci. Technol., 18:330-333, 1984.

15. Yamasaki, H., Kuwata, K., and Miyamoto, H., "Effects of Ambient Temperature on Aspects of Airborne Polycyclic Aromantic Hydrocarbons", Envir. Sci. Technol., Vol. 16, pp. 189-194, 1982.

16. Chuang, J.C., Hannan, S.W. and Kogtz, J. R., "Comparison of Polyurethane Foam and XAD-2 Resin as Collection Media for Polynuclear Aromantic Hydrocarbons in Air," U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Methods Development and Analysis Division, Research Triangle Park, N.C., EPA-600/4-86-034, December, 1986.

17. Chuang, J. C., Mack, G. A., Mondron, P. J. and Peterson, B. A., "Evaluation of Sampling and Analyjtical Methodology for Polynuclear Aromatic Compounds in Indoor Air," Environmental Protection Agency, Environmental, Monitoring Systems Laboratory, Methods Development and Analysis Division, Research Triangle Park, N.C., EPA-600/4-85-065, January, 1986.

18. Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH, EPA-600/4-82-057, July 1982.

19. ASTM Annual Book of Standards, Part 31, D 3694. "Standard Practice for Preparation of Sample Containers and for Preservation," American Society for Testing and Materials, Philadelphia, PA, p. 679, 1980.

20. Burke, J.A., "Gas Chromatography for Pesticle Residue Analysis; Some Practical Aspects," Journal of the Association of Official Analytical Chemists, Vol. 48, p. 1037, 1965.

21. Cole, T., Riggins, R., and Glaser, J., "Evaculation of Method Detection Limits an Analytical Curve for EPA Method 610 - PNAs," International Symposium on Polynuclear Aromantic Hydrocarbons, 5th, Battelle Columbus Laboratory, Columbus, Ohio, 1980.

22. "Handbook of Analytical Quality Control in Water and Wastewater Laboratories, "U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268, EPA-600/4-79-019, March, 1979.

23. ASTM Annual Book of Standards, Part 31, D 3370, "Standard Practice for Sampling Water," American Society for Testing and Materials, Philadelphia PA, p. 76, 1980.

24. Protocol for the Collection and Analysis of Volatile POHC's (Principal Organic Hazardous Constituents) using VOST (Volatile Organic Sampling Train), PB84-170042, EPA-600/8-84-007, March, 1984.

25. Sampling and Analysis Methods for Hazardous Waste Combustion - Methods 3500, 3540, 3610, 3630, 8100, 8270, and 8310; Test Methods For Evaluating Solid Waste (SW-846), U.S. EPA, Office of Solid Waste, Washington, D.C.

26. Chuang, C.C. and Peterson, B.A., "Review of Sampling and Analysis Methodology for Polunuclear Aromantic Compounds in Air from Mobile Sources", Final Report, EPA-600/S4-85-045, August, 1985.

27. "Measurement of Polycyclic Organic Matter for Environmental Assessment," U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Research Triangle Park, N.C., EPA-600/7-79-191, August, 1979.

28. "Standard Operating Procedure No. FA 113C: Monitoring For Particulate and Vapor Phase Pollutants Using the Portable Particulate/Vapor Air Sampler," J.L. Hudson, U.S. Environmental Protection Agency, Region VII, Environmental Monitoring and Compliance Branch, Environmental Services Division, Kansas City, Kansas, March, 1987.

29. Technical Assistance Document for Sampling and Analysis of Toxic Organic Compounds in Ambient Air, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Quality Assurance Division, Research Triangle Park, N.C., EPA-600/4-83-027, June, 1983.

30. Winberry, W. T., Murphy, N.T., Supplement to Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Quality Assurance Division, Research Triangle Park, N.C., EPA-600/4-87-006, September, 1986.

31. Riggins, R. M., Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Quality Assurance Division Research Triangle Park, N.C., EPA-600/4-84-041, April, 1984.

32. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II - "Ambient Air Specific Methods," Section 2.2 - "Reference Method for the Determination of Suspended Particulates in the Atmosphere," Revision 1, July, 1979, EPA-600/4-77-027A.

33. ASTM Annual Book of Standards, Part 31, D 3694. "Standard Practice for Preparation of Sample Containers and for Preservation," American Society for Testing and Materials, Philadelphia, PA, p. 679, 1980.

34. "HPLC Troubleshooting Guide - How to Identify, Isolate, and Correct Many HPLC Problems," Supelco, Inc., Supelco Park, Bellefonte, PA, 16823-0048, Guide 826, 1986.

35. "Carcinogens - Working With Carcinogens," Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Publication No. 77-206, August, 1977.

36. "OSHA Safety and Health Standards, General Industry," (29CFR1910), Occupational Safety and Health Administration, OSHA 2206, Revised, January, 1976.

37. "Safety in Academic Chemistry Laboratories," American Chemical Society Publication, Committee on Chemical Safety, 3rd Edition, 1979.

38. Hudson, J., "Monitoring for Particulate And Vapor Phase Pollutants Using A Portable Particulate/Vapor Air Sampler - Standard Operating Procedure No. SA-113-C", U.S. Environmental Protection Agency, Region VII, Environmental Services Division, 25 Funston Road, Kansas City, Kansas, 66115.

TABLE 1.0 FORMULAE AND PHYSICAL PROPERTIES OF SELECTIVE PAHs

	FORMULA	MOLECULAR WEIGHT	MELTING POINT °C	BOILING POINT °C	CASE #
Acenaphthene	$C_{12}H_{10}$	154.21	96.2°	279	83-32-9
Acenaphthylene	$C_{12}H_8$	152.20	92-93	265-275	208-96-8
Anthracene	$C_{14}H_{10}$	178.22	218°	342	120-12-7
Benzo(a)anthracene	$C_{18}H_{12}$	228.29	158-159	-	56-55-3
Benzo(a)pyrene	$C_{20}H_{12}$	252.32	177°	310-312	50-32-8
Benzo(b)fluoranthene	$C_{20}H_{12}$	252.32	168	-	205-99-2
Benzo(e)pyrene	$C_{20}H_{12}$	252.32	178-179	-	192-92-2
Benzo(g,h,i)perlene	$C_{22}H_{12}$	276.34	273	-	191-24-2
Benzo(k)fluoranthene	$C_{20}H_{12}$	252.32	217	480	207-08-9
Chrysene	$C_{18}H_{12}$	228.29	255-256	-	218-01-9
Dibenzo(a,h)anthracene	$C_{22}H_{14}$	278.35	262	-	53-70-3
Fluoranthene	$C_{16}H_{10}$	202.26	110	-	206-44-0
Fluorene	$C_{13}H_{10}$	166.22	116-117	293-295	86-73-7
Indeno(1,2,3-cd)pyrene	$C_{22}H_{12}$	276.34	161.5-163	-	193-39-5
Naphthalene	$C_{10}H_8$	128.16	80.2	217.9	91-20-3
Phenanthrene	$C_{14}H_{10}$	178.22	100°	340	85-01-8
Pyrene	$C_{16}H_{10}$	202.26	156	399	129-00-0

*Many of these compounds sublime.

TABLE 2.0 RETENTION TIMES FOR SELECTIVE PAHs FOR PACKED AND CAPILLARY COLUMNS

Compound	Packed[1]	Capillary[2]
Acenaphthene	10.8	16.8
Acenaphthylene	10.4	15.9
Anthracene	15.9	20.7
Benzo(a)anthracene	20.6	29.1
Benzo(a)pyrene	29.4	36.2
Benzo(b)fluoranthene	28.0	34.2
Benzo(ghi)perylene	38.6	48.4
Benzo(k)fluoranthene	28.0	34.4
Chrysene	24.7	29.3
Dibenzo(a,h)anthracene	36.2	46.1
Fluoranthene	19.8	24.3
Fluorene	12.6	18.1
Indeno(1,2,3-cd)pyrene	36.2	45.6
Naphthalene	4.5	11.0
Phenanthrene	15.9	20.6
Pyrene	20.6	25.0

[1]GC conditions: Chromosorb W-AW-DMCS (100/120 mesh) coated with 3% OV-17, packed in a 1.8-m long x 2 mm ID glass column, with nitrogen carrier gas at a flow rate of 40 mL/min. Column temperature was held at 100°C for 4 min. then programmed at 8°/minute to a final hold at 280°C.

[2]Capillary GC conditions: 30 meter fused silica SPB-5 capillary column; flame ionization detector, splitless injection; oven temperature held at 80 degrees C for 2 minutes, increased at 8 degrees/min. to 280 degrees C.

TABLE 3.0 DFTPP KEY IONS AND ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
51	30-60% of mass 198
68	Less than 2% of mass 69
70	Less than 2% of mass 69
127	40-60% of mass 198
197	Less than 1% of mass 198
198	Base peak, 100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	Greater than 1% of mass 198
441	Present but less than mass 443
442	Greater than 40% of mass 198
443	17-23% of mass 442

TABLE 4.0 GC AND MS OPERATING CONDITIONS

Chromatography	
Column	Hewlett-Packard Ultra #2 crosslinked 5% phenyl methyl silicone (50 m x 0.25 mm, 0.25 um film thickness) or equivalent
Carrier Gas	Helium velocity 20 cm^3/sec at 250°C
Injection Volume	Constant (1-3 uL)
Injection Mode	Splitless
Temperature Program	
Initial Column Temperature	45°C
Initial Hold Time	1 min
Program	45°C to 100°C in 5 min, then 100°C to 320°C at 8°C/min
Final Hold Time	15 min
Mass Spectrometer	
Detection Mode	Multiple ion detection, SIM mode

TABLE 5.0 CHARACTERISTIC IONS FROM GC/MS DETECTION FOR DEUTERATED INTERNAL STANDARDS AND SELECTED PAHs

Compound	M/Z
D_8-naphthalene	136
D_{10}-phenanthrene	188
Phenathrene	178
Anthracene	178
Fluoranthene	202
D_{10}-pyrene	212
Pyrene	202
Cyclopenta[c,d]pyrene	226
Benz[a]anthracene	228
D_{12}-chrysene	240
Benzo[e]pyrene	252
D_{12}-benzo[a]pyrene	264
Benzo[a]pyrene	252

TABLE 6.0 CHARACTERISTIC IONS FROM GC/MS DETECTION FOR SELECTED PAHs

Compound	Primary		Secondary
Acenaphthene	154	153	152
Acenaphthylene	152	151	153
Anthracene	178	179	176
Benzo(a)anthracene	228	229	226
Benzo(a)pyrene	252	253	125
Benzo(b)fluoranthene	252	253	125
Benzo(ghi)perylene	276	138	277
Benzo(k)fluoranthene	252	253	125
Chrysene	228	226	229
Dibenzo(a,h)anthracene	278	139	279
Fluoranthene	202	101	203
Fluorene	166	165	167
Indeno(1,2,3-cd)pyrene	276	138	227
Naphthalene	128	129	127
Phenanthrene	178	179	176
Pyrene	202	200	203

TABLE 7.0. COMMERCIAL AVAILABLE COLUMNS FOR PAH ANALYSIS USING HPLC

Company	Column Identification	Column Name
The Separation Group P.O. Box 867 Hesperia, California 92345	201-TP	VYDAC
Rainin Instrument Company Mack Road Wasurn, MA 01801-4626	Ultrasphere - ODS	ALEX
Supelco, Inc. Supelco Park Bellefonte, PA 16823-0048	LC-PAH	Supelcosil
DuPont Company Biotechnology Systems Barley Mill Plaza, P24 Wilmington, DE 19898	ODS	Zorbax
Perkin-Elmer Corp. Corporate Office Main Avenue Norwalk, CT 06856	HC-ODS	Sil-X
Waters Associates 34-T Maple St. Milford, MA 01757	u-Bondapak	NH_3 u-Bondapak

TABLE 8.0. TYPICAL RETENTION TIME FOR SELECTIVE PAHs BY HPLC SEPARATION AND DETECTION

Compound	Retention Times (minutes) HPLC Conditions			
	Condition A		Condition B	
	Fluorescence	UV	Fluorescence	UV
Acenaphthene		20.5		18.0
Acenaphthylene		18.5		15.8
Anthracene	23.4		21.0	21.0
Benzo(a)anthracene	28.5		26.3	26.3
Benzo(a)pyrene	33.9		31.1	31.1
Benzo(b)fluoranthene	31.6		29.3	29.3
Benzo(e)pyrene			31.1	
Benzo(ghi)perylene	36.3		33.9	33.9
Benzo(k)fluoranthene	32.9		30.2	30.2
Chrysene	29.3		26.7	
Dibenzo(a,h)anthracene	35.7		32.7	32.7
Fluoranthene	24.5		22.5	22.5
Fluorene		21.2	18.5	18.5
Indeno(1,2,3-cd)pyrene	37.4		34.6	34.6
Naphthalene		16.6		14.0
Phenanthrene	22.1		19.9	19.9
Pyrene	25.4		23.4	23.4

Condition A HPLC parameters: Reverse phase HC-ODS Sil-X, 5 micron particle size, in a 250-mm x 2.6-mm I.D. stainless steel column. Isocratic elution for 5 min using acetonitrile/water (4:6)(v/v), then linear gradient elution to 100% acetonitrile over 25 min at 0.5 mL/min flow rate. If columns having other internal diameters are used, the flow rate should be adjusted to maintain a linear velocity of 2 mm/sec.

Condition B HPLC parameters: Reverse phase VYDAC 201 TP 5415, 5 micron particle size, in a .46 x 25 cm stainless steel column. Isocratic elution for 10 min using acetonitrile/water (4:6)(v/v), then linear gradient elution to 100% acetonitrile for 10 minutes then linear gradient to 40/60 acetonitrile for 10 minutes at 15 mL/min.

TABLE 9.0. RETENTION TIMES (RT) AND MINIMUM DETECTION LIMITS (MDLs) FOR SELECTED PAHs USING ULTRAVIOLET AND FLOURESCENCE DETECTION

	Ultraviolet Detector		Flourescence Detector	
PAH	RT	MDL	RT	MDL
Naphthalene	14.0	250pg/uL		
Acenaphthylene	15.85	250pg/uL		
Acenaphthene	18.0	250pg/uL		
Fluorene	18.5	50pg/uL	18.5	5pg/uL
Phenanthrene	19.9	50pg/uL	19.9	10pg/uL
Anthracene	21.0	50pg/uL	21.0	50pg/uL
Fluoranthene	22.5	50pg/uL	22.5	10pg/uL
Pyrene	23.4	50pg/uL	23.4	5pg/uL
Benzo(a)anthracene	26.3	50pg/uL	26.3	5pg/uL
Chrysene	26.7	50pg/uL	26.7	5pg/uL
Benzo(b)fluoranthene	29.3	50pg/uL	29.3	10pg/uL
Benzo(k)fluoranthene	30.2	50pg/uL	30.2	5pg/uL
Benzo(a)pyrene	31.1	50pg/uL	31.1	5pg/uL
Dibenzo(a,h)anthracene	32.7	50pg/uL	32.7	5pg/uL
Benzo(ghi)perylene	33.9	50pg/uL	33.9	5pg/uL
Indeno(1,2,3-cd)pyrene	34.6	50pg/uL	34.6	50pg/uL

RT = Retention time in minutes
MDL = Minimum detection limit

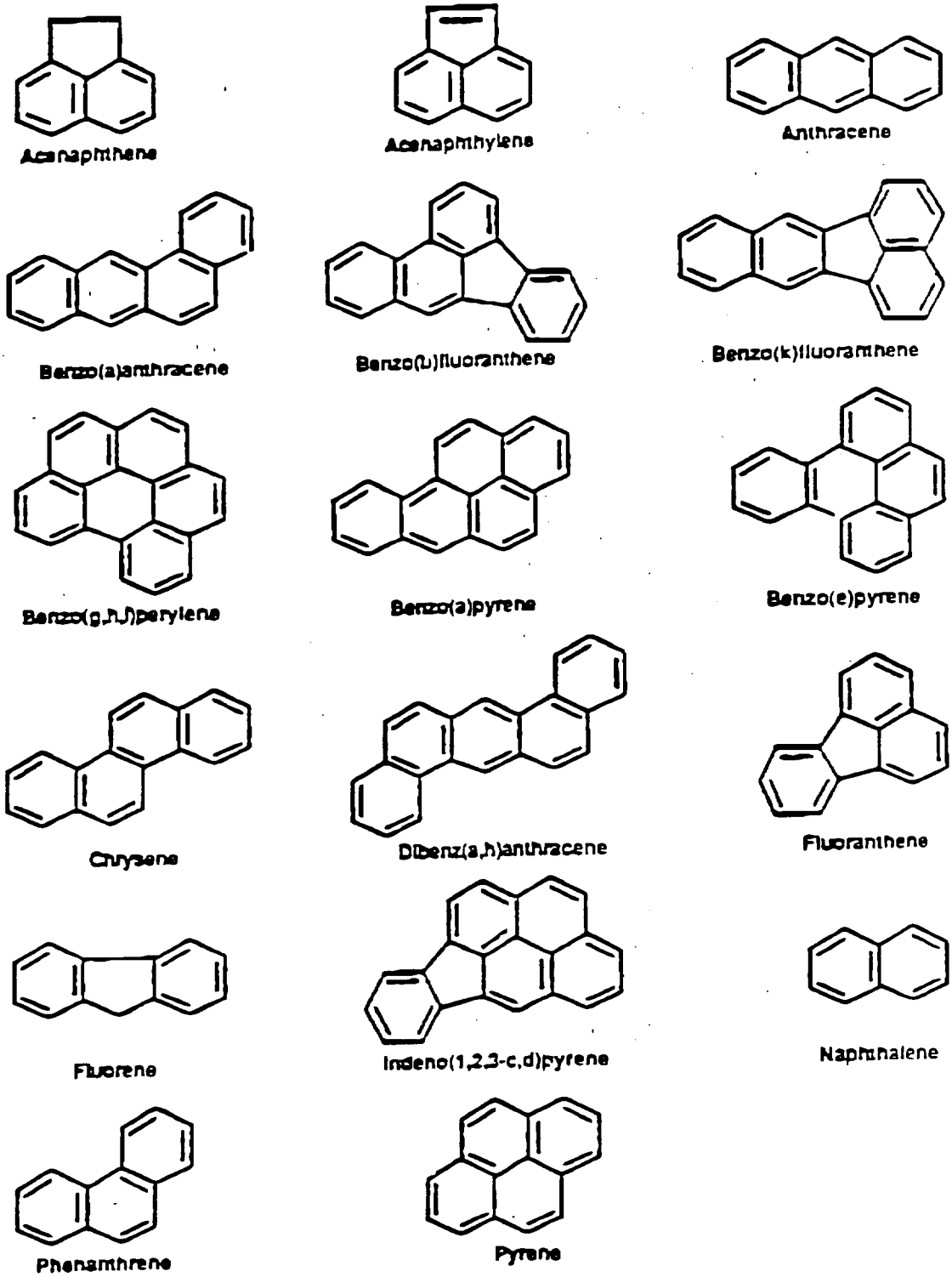

FIGURE 1.0 RING STRUCTURE OF SELECTIVE PAHs.

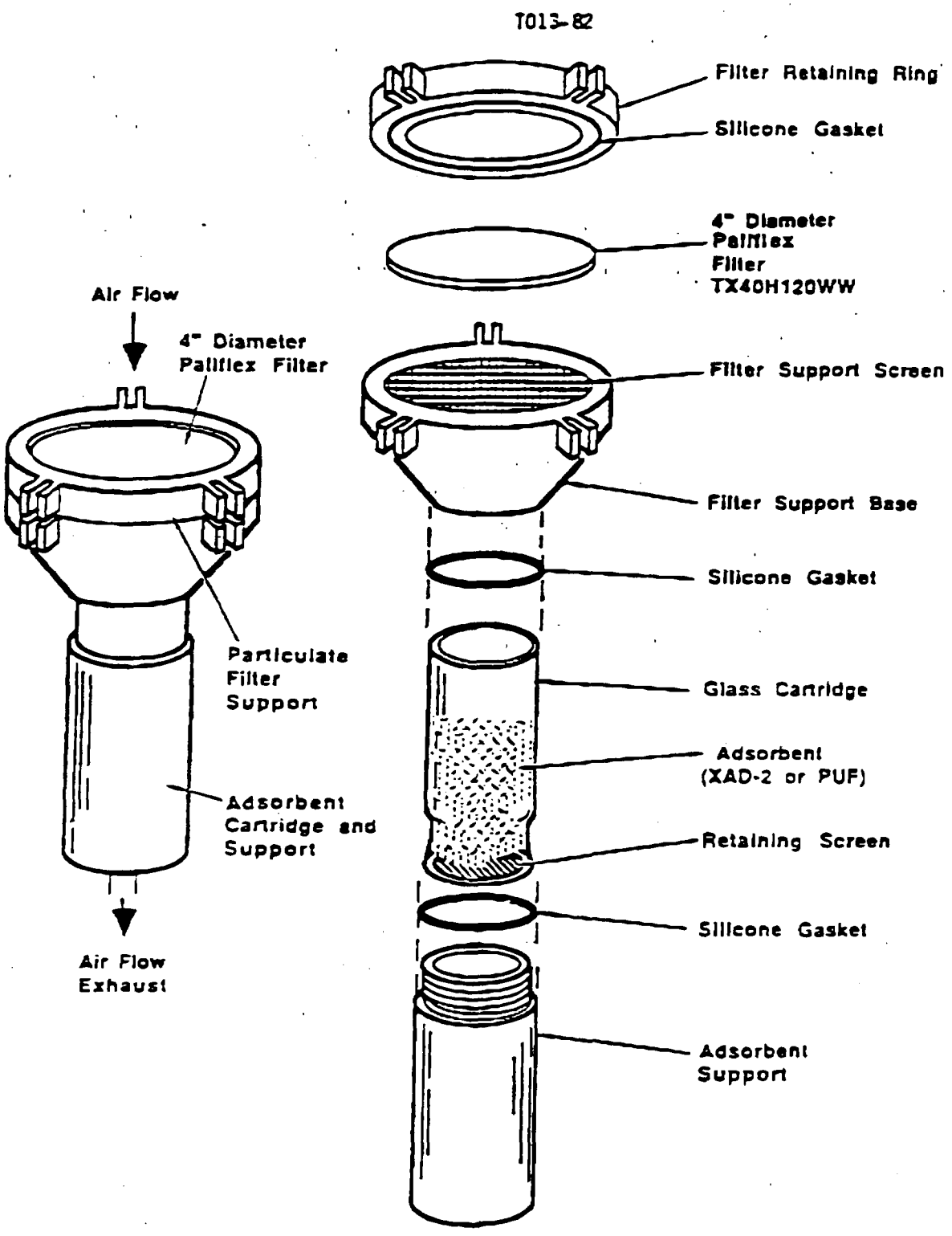

FIGURE 2.0 GENERAL METAL WORKS SAMPLING HEAD

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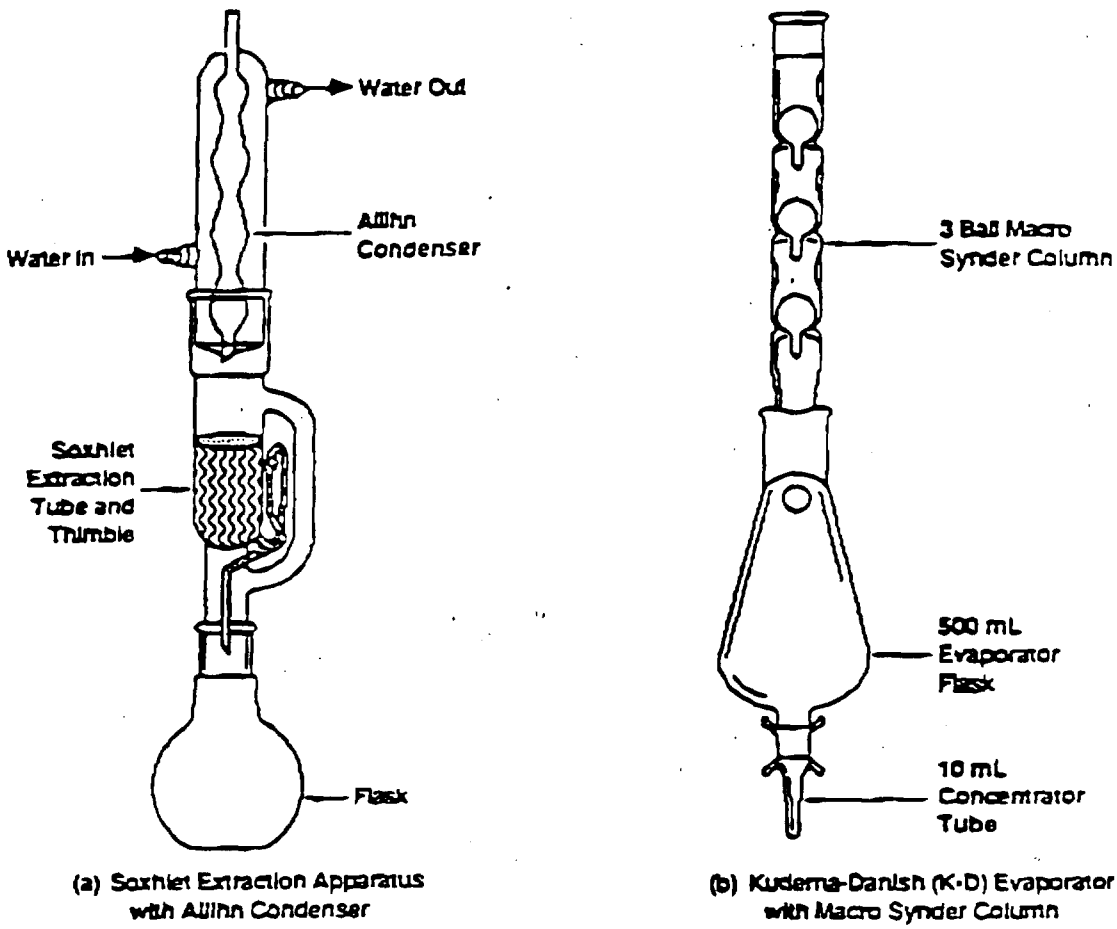

(a) Soxhlet Extraction Apparatus with Allihn Condenser

(b) Kuderna-Danish (K-D) Evaporator with Macro Synder Column

(c) Silica Gel Clean-up Column

FIGURE 3. APPARATUS USES IN SAMPLING ANALYSIS.

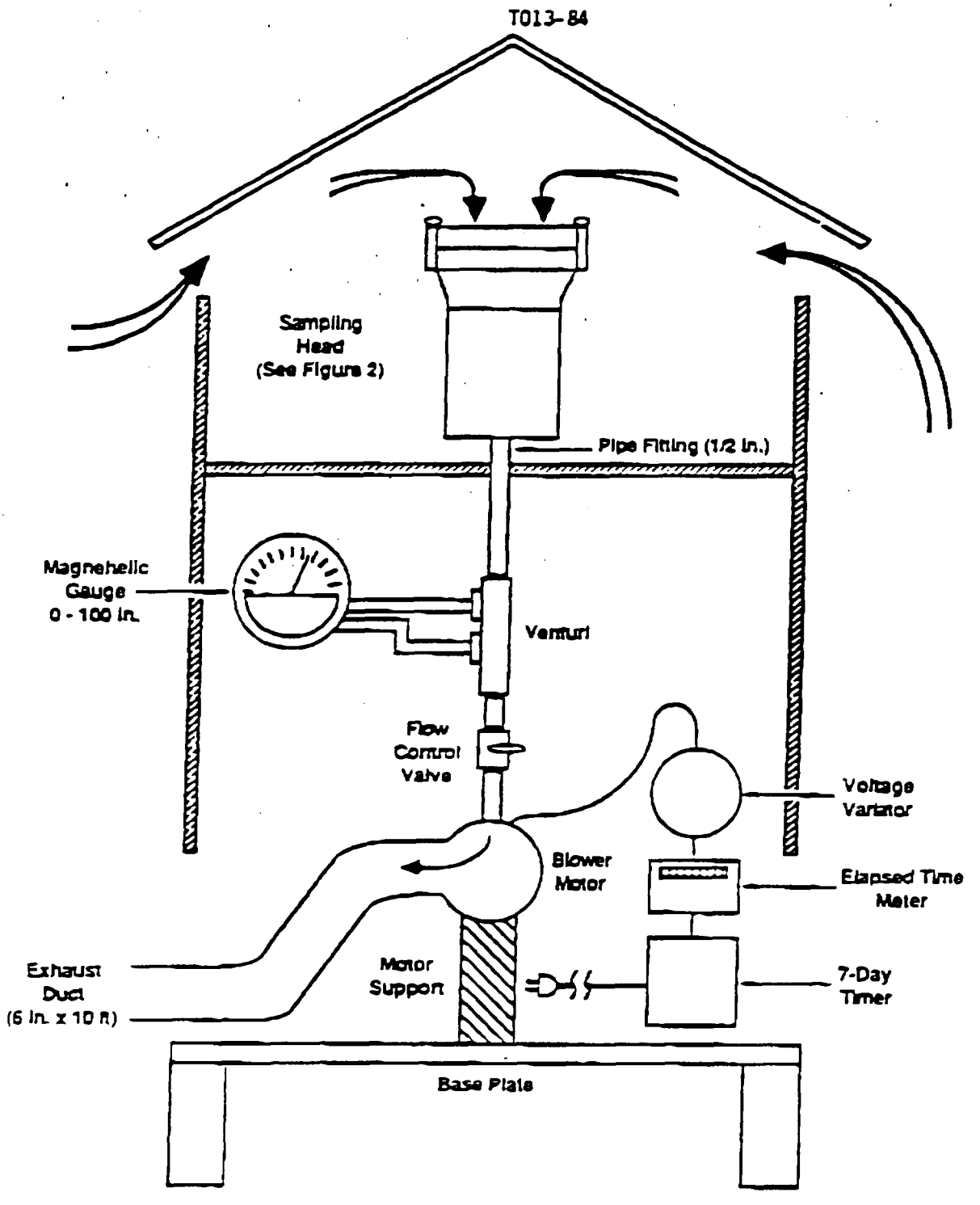

FIGURE 4. MODIFIED HIGH VOLUME AIR SAMPLER

GENERAL METAL WORKS MODEL PS-1 SAMPLER

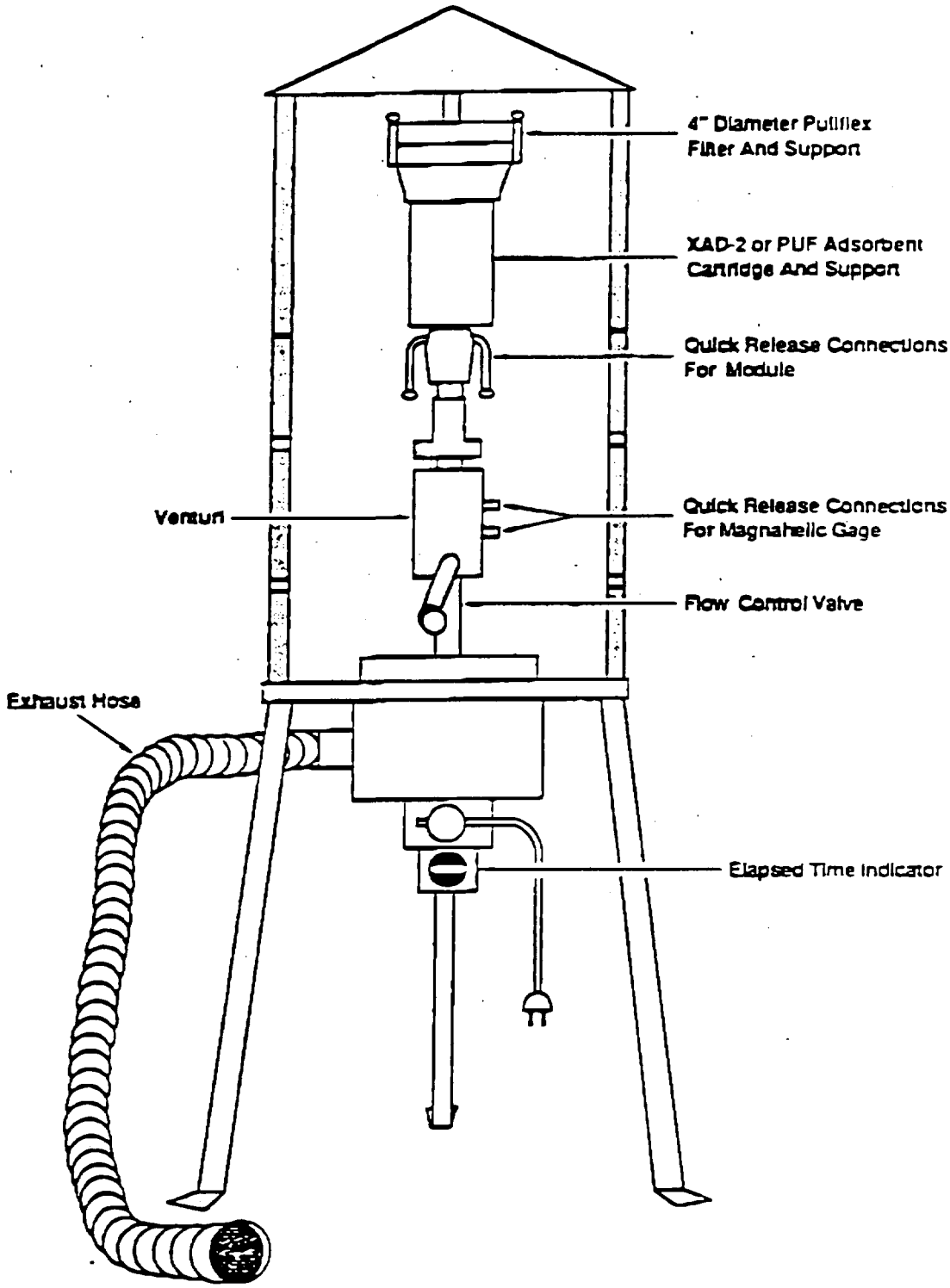

FIGURE 5. PORTABLE HIGH VOLUME AIR SAMPLER

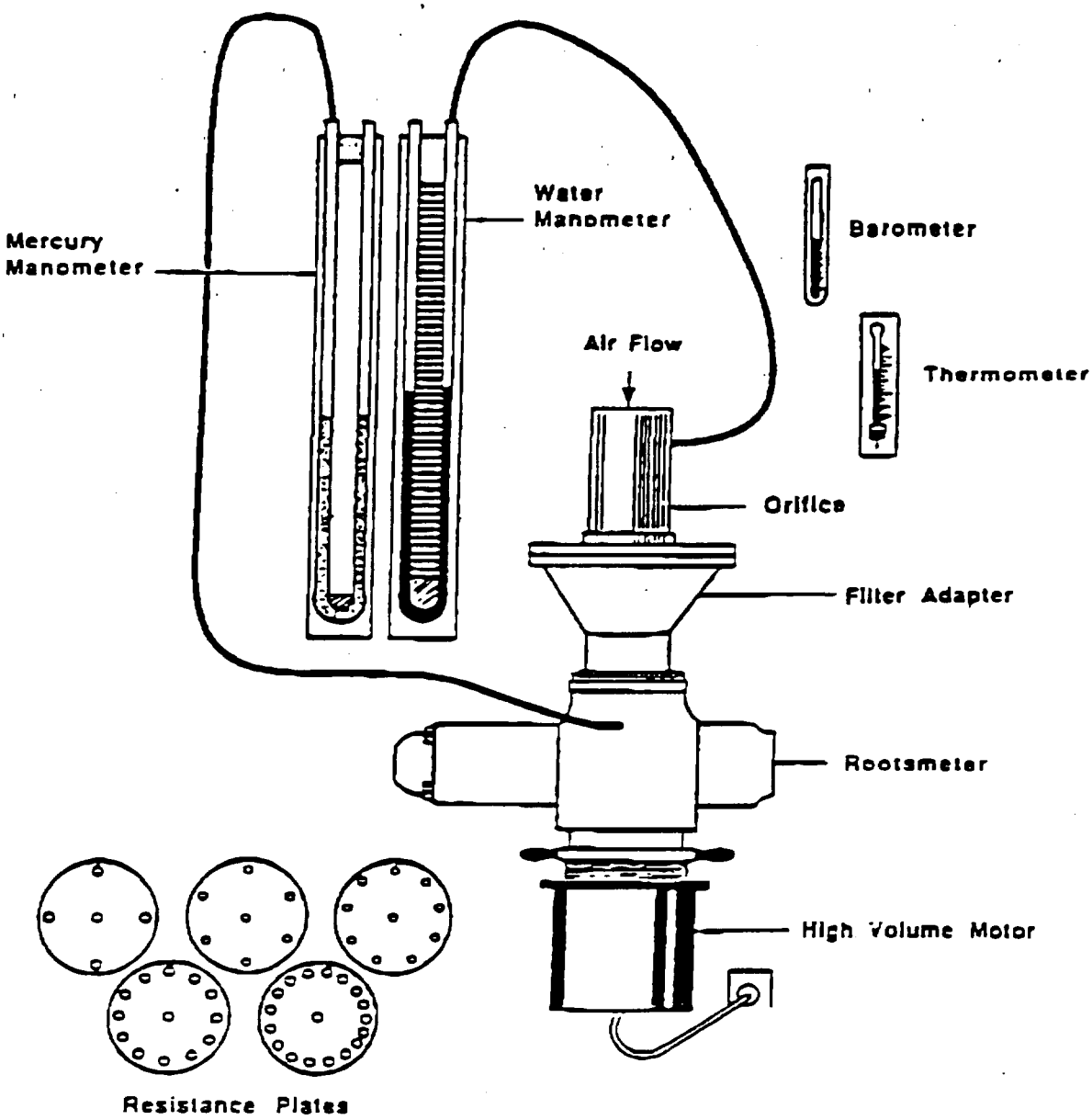

FIGURE 6. LABORATORY ORIFICE CALIBRATION SETUP

T_1 _____ °C _____ K

P_1 _____ mm Hg

Orifice No. _____

Roots Meter No. _____

Name _____

Date _____

Resistance Plates (No. of Holes)	Air Volume Measured By Roots meter V_m		Standard Volume V_{std} (std m^3)	Time For Air Volume To Pass Through Roots meter Θ (min)	Roots Meter Pressure Differential ΔP (mm Hg)	Pressure Drop Across Orifice ΔH (in. H_2O)	x-Axis Standard Flow Rate Q_{std} (std m^3/min)	y-Axis $\frac{\sqrt{\Delta H (P_1 / P_{std})}(298 / T_1)}{\text{Value}}$
	(ft^3)	(m^3)						
5	200	5.66						
7	200	5.66						
10	300	8.50						
13	300	8.50						
18	300	8.50						

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Factors: $(ft^3)\left(0.02832 \frac{m^3}{ft^3}\right) = m^3$ and (in. Hg) $25.4\left(\frac{\text{mm Hg}}{\text{in. Hg}}\right) = \text{mm Hg}$.

Calculation Equations: 1. $V_{std} = V_m \left(\frac{P_1 - \Delta P}{P_{std}}\right)\left(\frac{T_{std}}{T_1}\right)$ Where: $T_{std} = 298$ K, $P_{std} = 760.0$ mm Hg 2. $Q_{std} = \frac{V_{std}}{\Theta}$

FIGURE 7. ORIFICE CALIBRATION DATA SHEET.

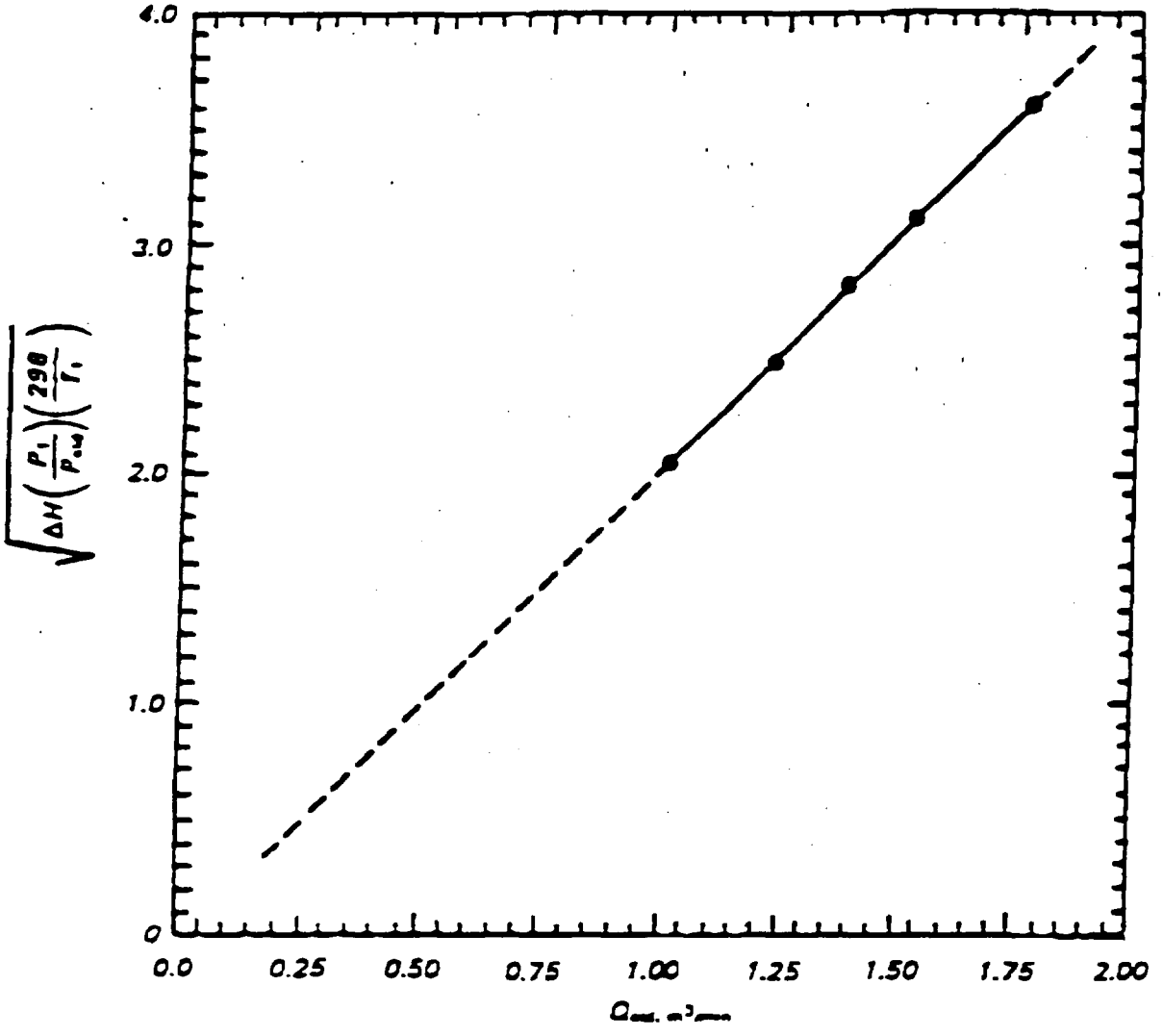


FIGURE 8. ORIFICE METER CALIBRATION CURVE

Performed by _____ Calibration Orifice _____ S/N _____ Ambient Temperature _____ °C

Date/Time _____ Manometer S/N _____ Bar. Press. _____ mm Hg

Sampler S/N	Variac Setting V	Timer OK? Yes/No	Flow Rate Transfer Standard		Sampler Venturi Data		Comments
			Manometer In. H_2O	Q_{std} [a]	Magnehelic, In. H_2O	Q_{ma} [b]	

[a] From Calibration Curve For Flow Rate Transfer Standard (Section 11.2.1).

[b] From Calibration Curve for Venturi Tube Using Flow Rate Transfer Standard (Section 11.2.2.9).

TO1A-89

FIGURE 9. FIELD CALIBRATION DATA SHEET

Sampler Site _____

Sampler Location _____

Date _____

	Before	After
Barometric Pressure		
Ambient Temperature		

Site _____ Date _____ Performed By _____

Sampler S/N	Sampling Location I.D.	Height Above Ground	Identification No.		Sampling Period		Totaling Sampling Time, min.	Pump Timer Hr. Min.	Sampler Flow Check[1]				
			Filter	XAD-2 or PUF	Start	Stop			Manometer Δ H, Inches of Water	Q_{std}	M	Q_{std}	Within ± 10%

TO13-90

[1] Must Be Performed Before and After Each Sampling Period

Checked By _____

Date _____

FIGURE 10. FIELD TEST DATA SHEET.

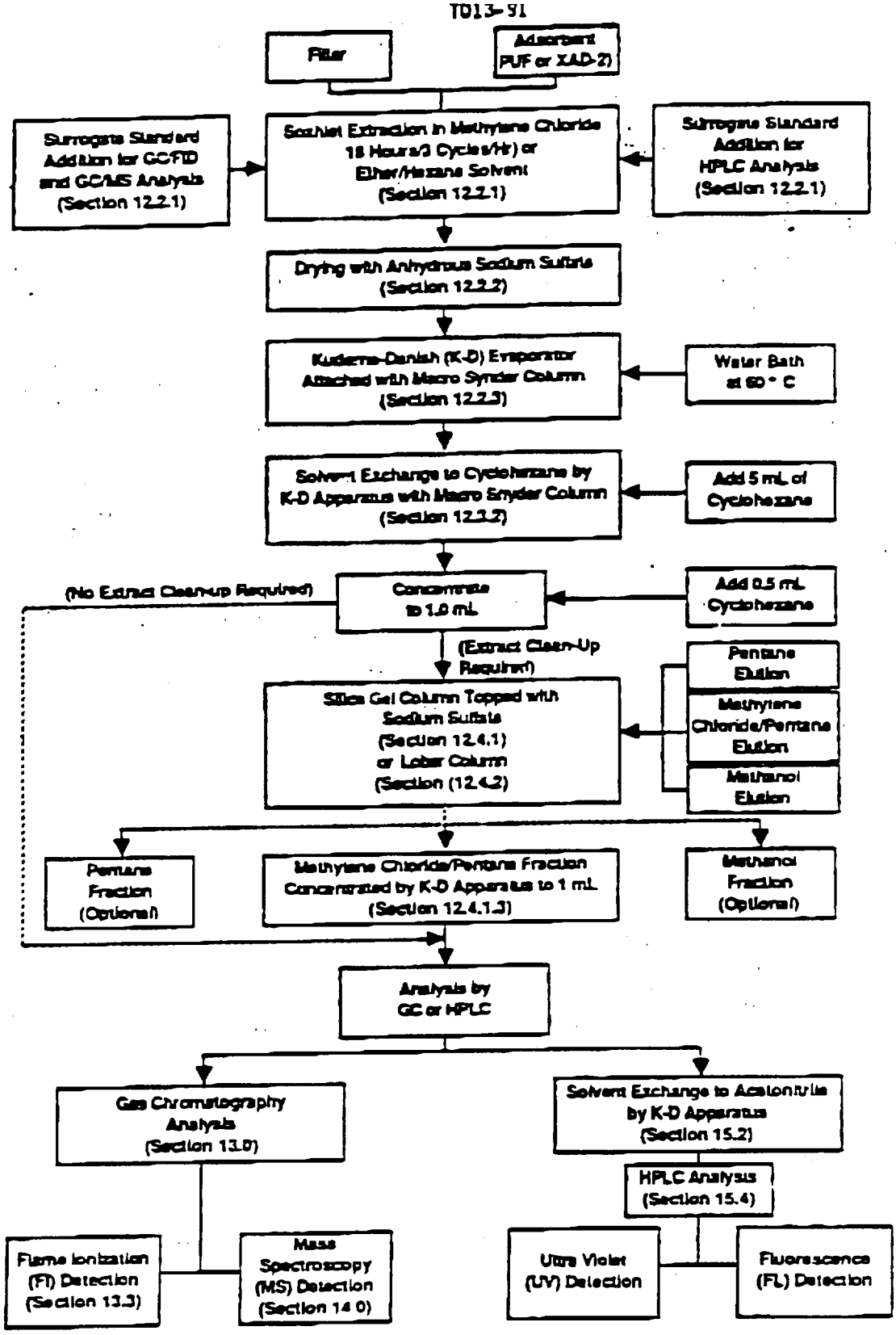


FIGURE 11.0. SAMPLE CLEAN-UP, CONCENTRATION, SEPARATION AND ANALYSIS SEQUENCE

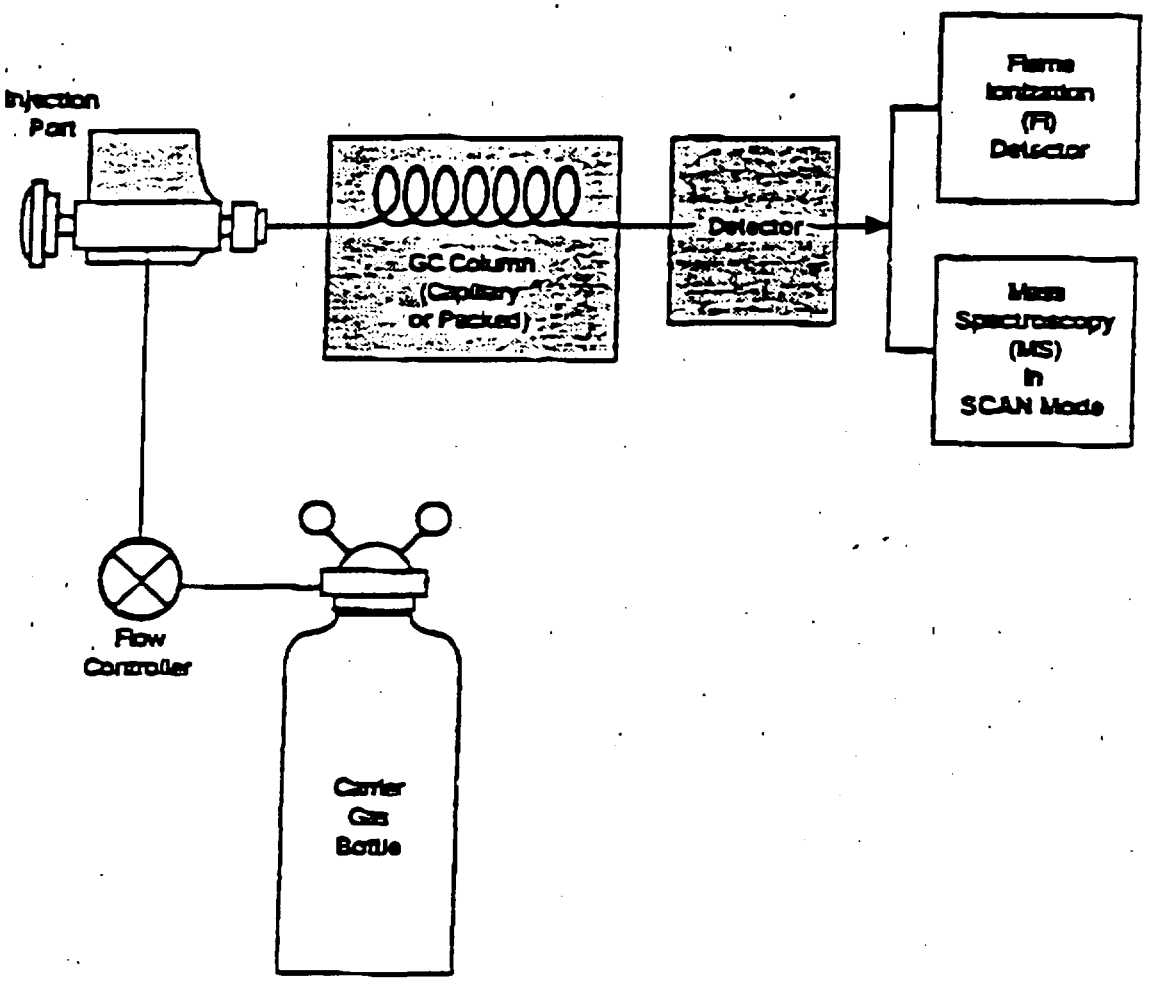


FIGURE 12.0 GC SEPARATION WITH SUBSEQUENT FLAME IONIZATION (FI) OR MASS SPECTROSCOPY (MS) DETECTION.

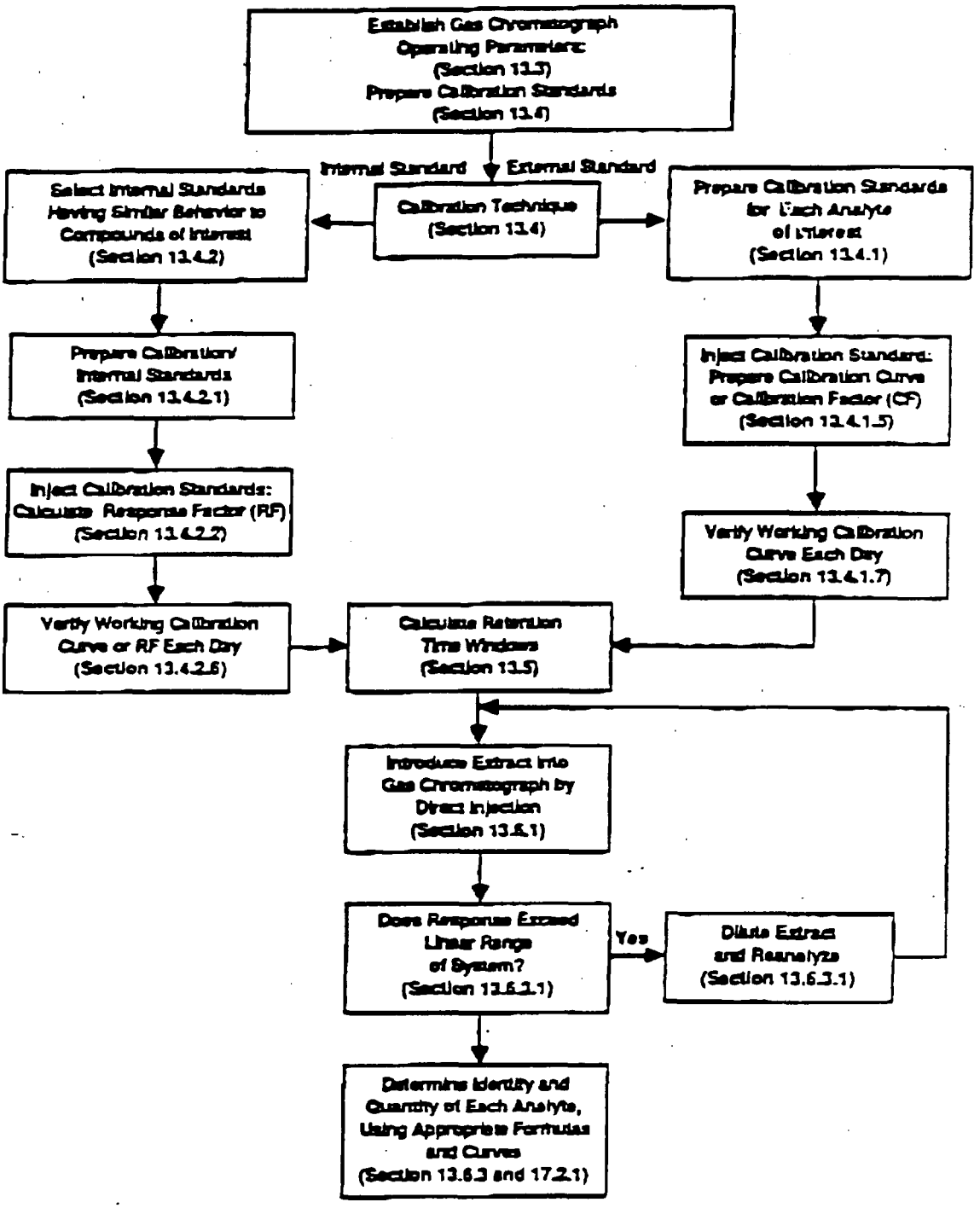
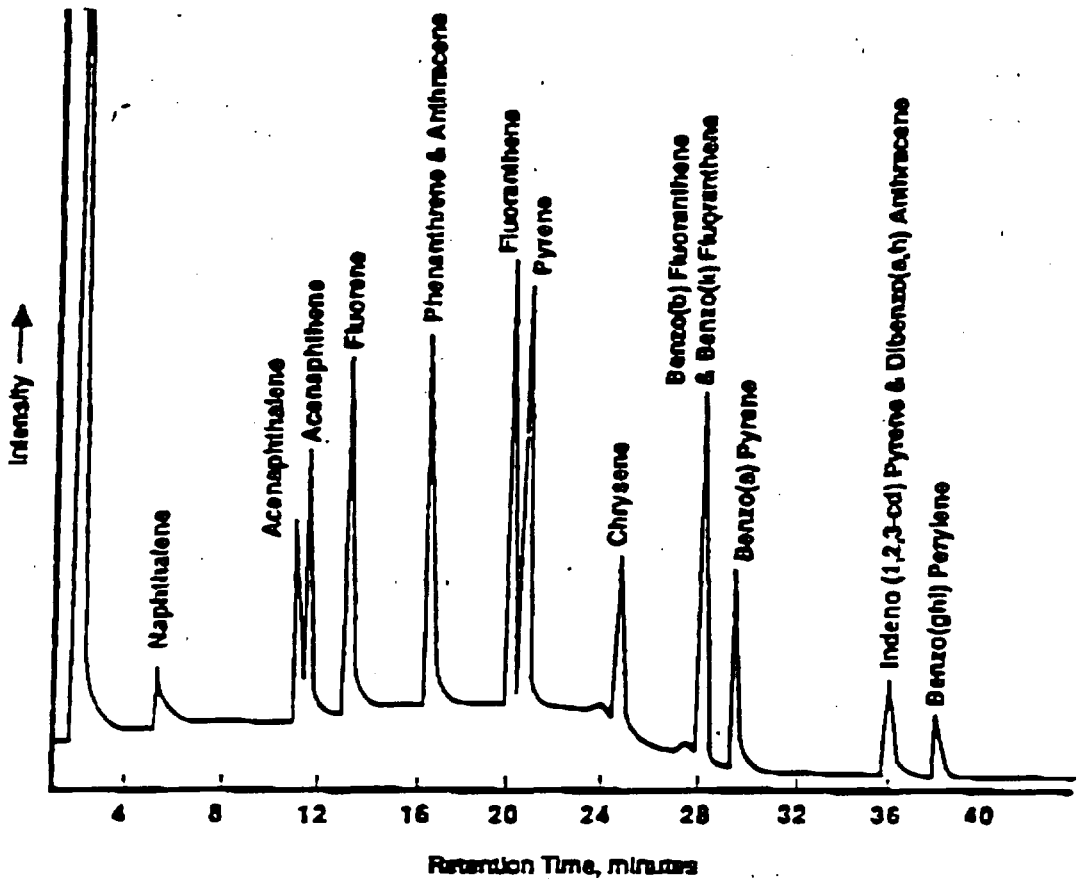


FIGURE 13.0 GC CALIBRATION AND RETENTION TIME WINDOW DETERMINATION.



Column: 3% OV-17 on Chromosorb W-AW-DCMS
Program: 100 °C. 4 min., 8 ° per min. to 280 °C.
Detector: Flame Ionization

FIGURE 14.0 TYPICAL CHROMATOGRAM OF SELECTIVE PNAs BY GC EQUIPPED WITH FI DETECTOR

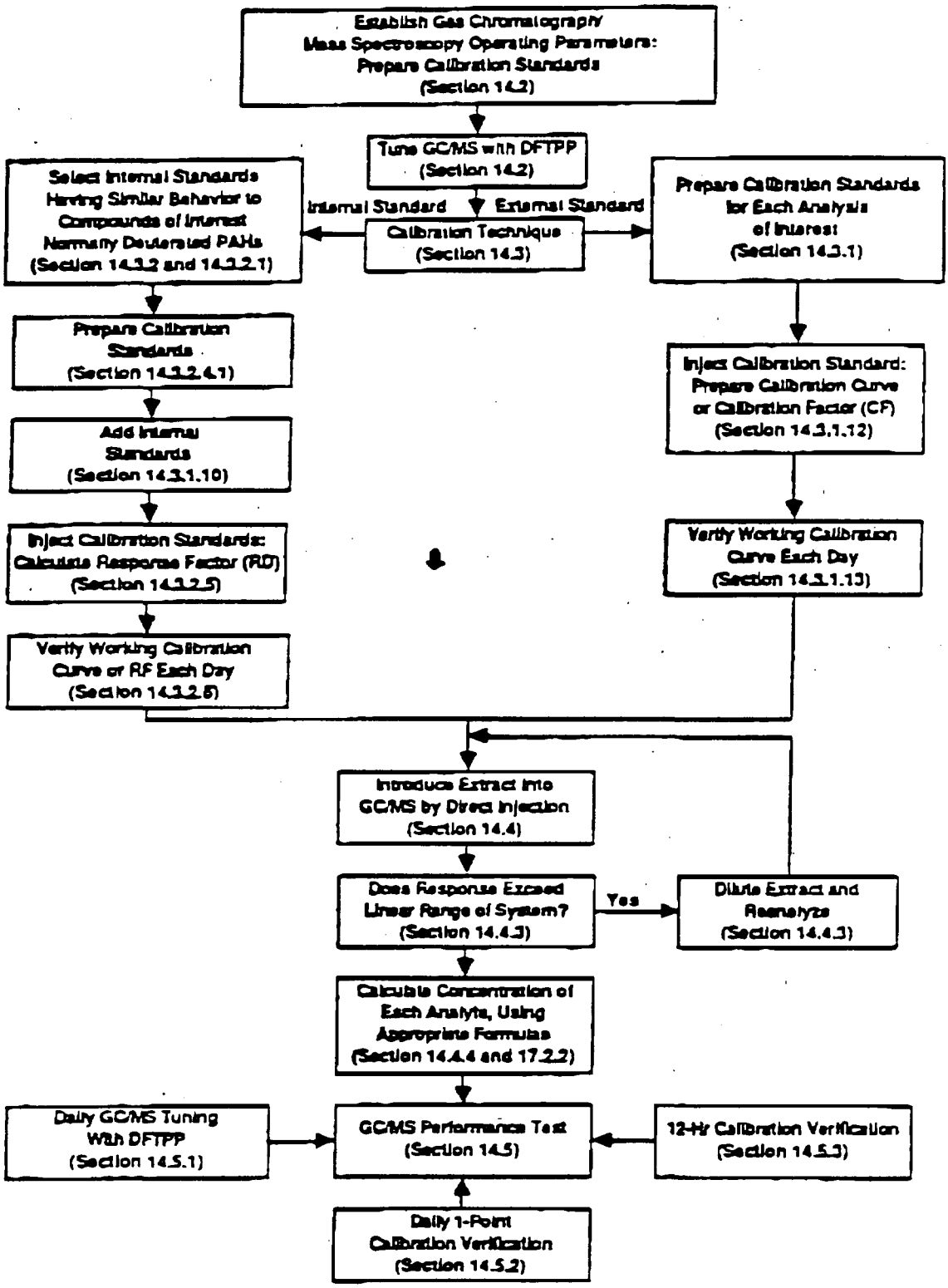


FIGURE 15.0 GC/MS CALIBRATION AND ANALYSIS.

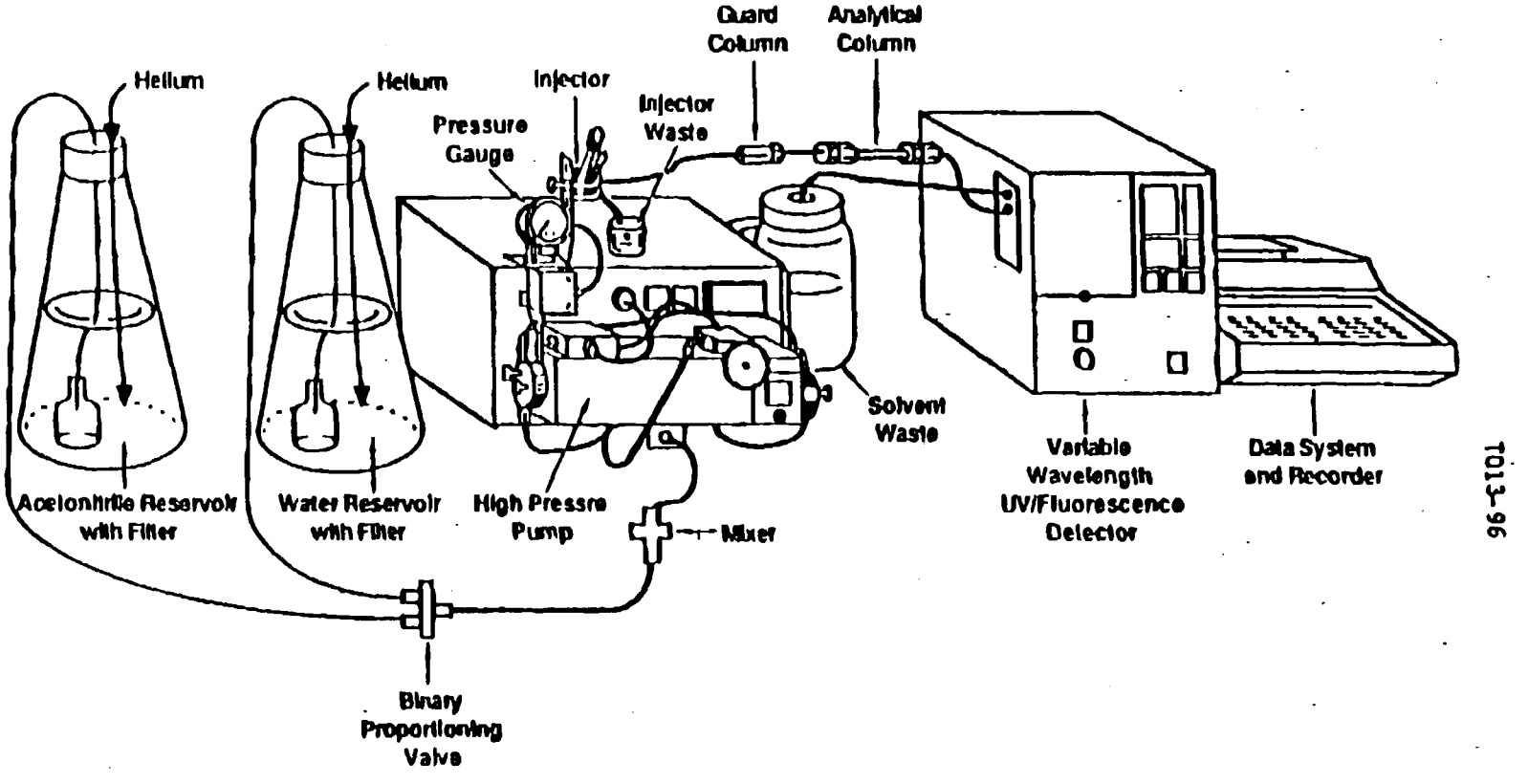


FIGURE 16. IMPORTANT COMPONENTS OF AN HPLC SYSTEM.

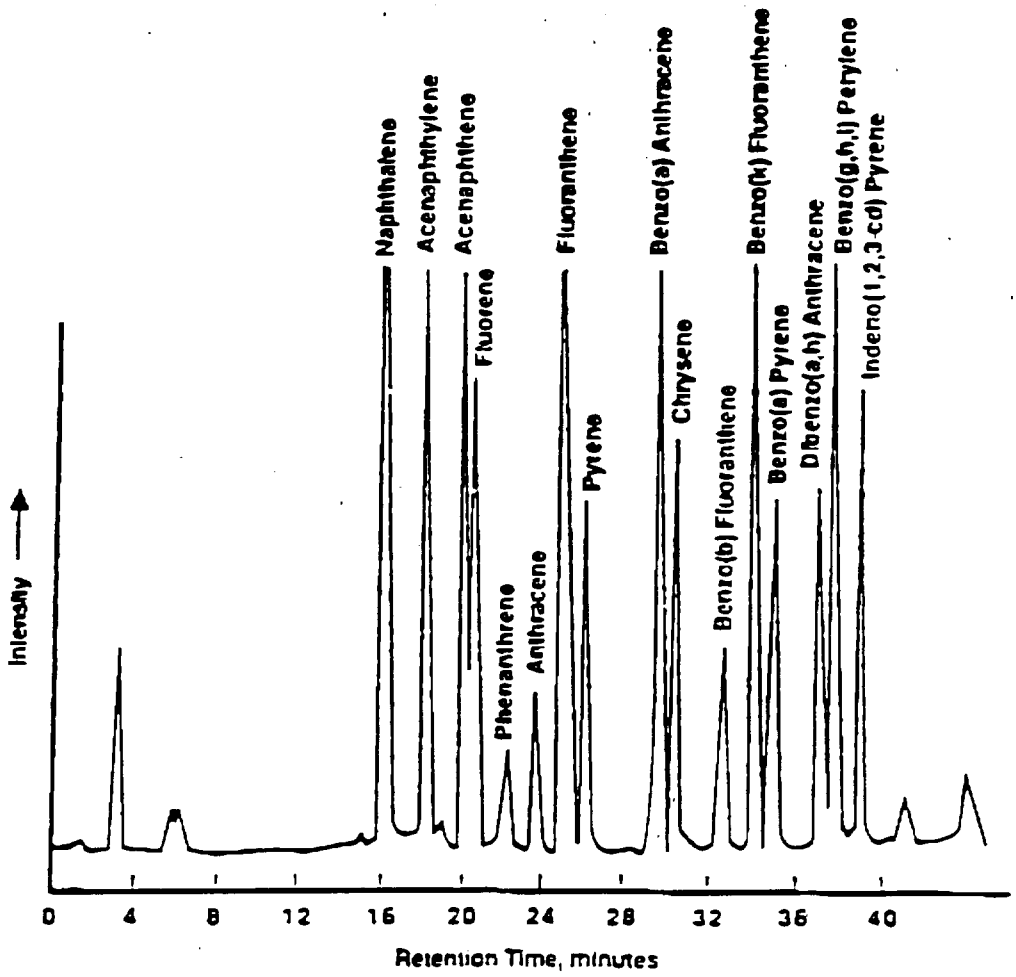


FIGURE 17.0 TYPICAL CHROMATOGRAM OF SELECTIVE PAHs ASSOCIATES WITH HPLC ANALYSIS WITH FLUORESCENCE DETECTION.

Soil, Ground Water, Surface Water, Sediment, and Air Sampling
QUALITY ASSURANCE PROJECT PLAN

Sauget Area 1 Support Sampling Plan
Sauget and Cahokia, Illinois
Volume 2B

Remediation Technology Group
Solutia Inc.
St. Louis, Missouri

August 1999

O'BRIEN & GERE
ENGINEERS, INC.

Soil, Ground Water, Surface Water, Sediment, and Air Sampling QUALITY ASSURANCE PROJECT PLAN

FOR THE SAUGET AREA 1 SUPPORT SAMPLING PLAN IN SAUGET AND CAHOKIA, ILLINOIS Volume 2B

REVISION: 0

August 1999

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10040/23548

Soil, Ground Water, Surface Water, Sediment, and Air Sampling
QUALITY ASSURANCE PROJECT PLAN

Sauget Area 1 Support Sampling Plan
Sauget and Cahokia, Illinois
Volume 2B

Remediation Technology Group
Solutia Inc.
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August 1999

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D. Static head space gas chromatography standard operating procedure (SOP)

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Donald Harvan, Triangle Laboratories, Inc., Quality Assurance Officer

List of Acronyms/Abbreviations

%D	Percent difference
%R	Percent recovery
AOC	Administrative order by consent
APHA	American Public Health Association
ARARs	Applicable or relevant and appropriate requirements
AWWA	American Water Works Association
BFB	Bromofluorobenzene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract laboratory program
COCs	Constituents of concern
CRDL	Contract required detection limits
CS	Creek segments
DBMS	Database managment system
DQL	Data quality limits
DQO	Data quality objective
DSR	Duplicate sample result
EDD	Electronic disk deliverable
E&E	Ecology and Environment
EE/CA	Engineering evaluation/cost assessment
ERA	Ecological risk assessment
FCR	Field change request
FSP	Field sampling plan
GC/MS	Gas chromatograph/mass spectrometer
G&M	Geraghty & Miller
HHRA	Human health risk assessment
HRGC	High-resolution gas chromatography
HRMS	High-resolution mass spectrometry
ICP	Inductively coupled plasma
ICSAB	Interference check sample
IDL	Instrument detection limit
IEPA	Illinois Environmental Protection Agency
LCS	Laboratory control sample
MDL	Method detection limit
MS	Matrix spike

MS/MSD	Matrix spike/matrix spike duplicate
MSD	Matrix spike duplicate
NCP	National Contingency Plan
NIST	National Institute of Standards and Technology
NTU	Nephelometric turbidity unit
OM	Operations manager
OSR	Original sample result
PCBs	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzodiozin
PCDF	Polychlorinated dibenzofuran
PID	Photoionization detector
PM	Project manager
ppb	Parts per billion
PQL	Practical quantitation limit
PRP	Potentially responsible party
QA/QC	Quality assurance/quality control
QAM	Quality assurance management
QAO	Quality assurance officer
QAPP	Quality assurance project plan
RAM	Real-time aerosol monitor
RI/FS	Remedial investigation/feasibility study
RPD	Relative percent difference
RPM	Remedial project manager
RRFs	Relative response factors
RSD	Relative standard deviation
SOP	Standard operating procedure
SOW	Statement of work
SVOC	Semi-volatile organic compound
TOC	Total organic carbon
TPH	Total petroleum hydrocarbon
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WPCF	Water Pollution Control Federation

1. Project description

1.1. Introduction

This Quality Assurance Project Plan (QAPP) has been prepared by O'Brien & Gere Engineers, Inc. (O'Brien & Gere) on behalf of Solutia Inc. (Solutia) as part of the Support Sampling Plan at the Sauget Area 1 Site (the site) located along Dead Creek in the villages of Sauget and Cahokia, Illinois. This QAPP provides objectives, organization, functional activities, and specific Quality Assurance (QA) and Quality Control (QC) activities for sampling, sample handling and storage, chain of custody, and laboratory and field analysis efforts associated with sampling of environmental media at the site and is one component of the Engineering Evaluation/Cost Assessment and Remedial Investigation/Feasibility Study (EE/CA and RI/FS) Support Sampling Plan (SSP).

This QAPP was developed using the following documents as guidance:

- USEPA Region V *Superfund Model Quality Assurance Project Plan (QAPP) Revision 1* (USEPA, 1996b)
- United States Environmental Protection Agency's (USEPA) *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans*, QAMS-005-80 (USEPA, 1980)
- USEPA *Requirements for Quality Assurance Project Plans for Environmental Data Operation*, USEPA QA/R-5, (USEPA, 1994b).

The following quality assurance topics are addressed in this QAPP:

- Project description
- Project organization and responsibilities
- Quality assurance objectives for measurement
- Sampling procedures
- Custody procedures

- Calibration procedures and frequency
- Analytical procedures
- Internal quality control checks
- Data reduction, validation, and reporting
- Performance and system audits
- Preventative maintenance
- Specific routine procedures used to assess data precision, accuracy, and completeness
- Corrective action
- Quality assurance reports to management.

1.2. Site description

The site description is presented in Section III of the Administrative Order by Consent (AOC) (USEPA, 1999) and in the Ecology and Environment, Inc. Data Report (Ecology and Environment Data Report), (Ecology and Environment, Inc., 1998). The source areas are designated as Sites I, H, G, L, M, and N, and Dead Creek Segments (CS) CS-A, CS-B, CS-C, CS-D, CS-E, and CS-F in the AOC and the Ecology and Environment Data Report.

1.3. Past data collection activities and background information

1.3.1. Site background

Sauget Area 1 is located in the villages of Sauget and Cahokia, St. Clair County, Illinois. The study area is centered on Dead Creek, an intermittent stream that is approximately 17,000 feet long, and its floodplain. The study area includes three closed municipal/industrial landfills (Sites G, H, and I), one backfilled wastewater impoundment (Site L), one flooded borrow pit (Site M), and one backfilled borrow pit (Site N). The study area also includes six creek segments:

Creek Segment A	Alton & Southern Railroad to Queeny Avenue
Creek Segment B	Queeny Avenue to Judith Lane
Creek Segment C	Judith Lane to Cahokia Street
Creek Segment D	Cahokia Street to Jerome Lane
Creek Segment E	Jerome Lane to Route 157
Creek Segment F	Route 157 to Old Prairie du Pont Creek

These sites and creek segments are shown on Figure 1 in the Solutia SSP..

1.3.2. Land use

During recent years, land use has been consistent in the area surrounding Dead Creek. In a 1988 report prepared for the Illinois Environmental Protection Agency (IEPA) (Expanded Site Investigation, Dead Creek Project Sites at Cahokia/Sauget, Illinois), Ecology and Environment indicated that "A wide variety of land utilization is present [in the study area]. The primary land use in the town [village] of Sauget is industrial, with over 50% of the land used for this purpose. Small residential, commercial, and agricultural properties are also interspersed throughout the town [village]. Significant land use features, in relation to individual project sites will be discussed below.

Land surrounding the Area 1 project sites is used for several purposes. A small residential area is located immediately east of Sites H and I, across Falling Springs Road. The nearest residence is approximately 200 feet from these sites. The Sauget Village Hall is also located on top of, or adjacent to, Site I .... South of Sites G and L are two small cultivated fields which are used for soybean production. These fields separate the sites from a residential area in the northern portion of Cahokia. Several small commercial properties are also found in the immediate vicinity of the Area 1 sites." These land use patterns are typical of Dead Creek east of its intersection with Route 3 (Mississippi Avenue). Immediately south of Route 3 there is a residential area. After this developed area, Dead Creek runs through undeveloped area until it reaches the lift station at Old Prairie du Pont Creek.

1.3.3. Climate

Geraghty and Miller, in a report prepared for Monsanto (Site Investigation for Dead Creek Segment B and Sites L and M, Sauget-Cahokia, Illinois, 1992), indicates that "The climate of the site(s) is continental with hot, humid summers and mild winters. Periods of extreme cold are short. The average annual rainfall in the area for the period from 1903 to 1983 was

35.4 inches; however, precipitation increased to 39.5 inches per year during the period between 1963 and 1988. The average annual temperature is 56°F; the highest average monthly temperature (79 °F) occurs in July and the lowest average monthly temperature (32 °F) occurs in January."

1.3.4. Hydrology

According to Ecology and Environment (1988), "the project area lies in the floodplain, or valley bottom, of the Mississippi River in an area known as the American Bottoms. For the most part, the topography consists of nearly flat bottom land, although many irregularities exist locally across the site areas.... Generally, the land surface in undisturbed areas slopes from north to south, and from the east toward the river. This trend is not followed in the immediately vicinity of [Sauget Area 1]. Elevations of Area 1 sites range from 410 to 400 ft above mean sea level (MSL) ... Little topographic relief is exhibited across individual sites, with the exception of Site G ...

Surface drainage in the project area is typically toward ... Dead Creek. However, significant site-specific drainage patterns are present. A brief description of surface drainage for individual sites is given below.

Site G - Drainage at Site G is generally east toward CS-B. A large depression exists in the south-central portion of the site. Surface runoff flows toward the depression [Note: As a result of an emergency response action by USEPA Region V in 1995, Site G is capped and surface water flow is directed radially away from the site].

Site H - Drainage at Site H is typically to the west toward CS-B. Several small depressions capable of retaining rainwater, are scattered across the site. Precipitation is these areas infiltrates the ground surface rather than draining from the site.

Site I - Drainage is generally to the west toward the two holding ponds which make up CS-A. [Note: Creek Segment A was closed under an IEPA-approved plan in 1990/91. Impacted sediments were removed and transported off-site for disposal, an HDPE membrane vapor barrier was installed, a storm water retention basin was constructed, and the site was backfilled to create a controlled-access truck parking lot. Water that used

to be impounded in CS-A is now drained to the new storm water retention basin.] CS-A also receives surface and roof drainage from the entire Cerro plant area located west of CS-A. This drainage flows through a series of storm sewers and effluent pipes. A large depression exists in the northern portion of Site I [Note: This depression no longer exists]. Precipitation in this area flows toward the depression.

Site L - Site L is a former subsurface impoundment which has subsequently been covered with highly permeable material (cinders). Runoff from the surface, although inhibited by the permeable nature of the cinders, flows toward CS-B.

Site M - Site M receives surface runoff from a small residential area located east and south of the site. Water in Site M eventually drains into CS-B through a cut-through located in the southwest corner of the site.

Site N - Because the excavation which constitutes Site N [is] only partially filled, it receives runoff from the surrounding area. The creek bank in this area (CS-B) [CS-C] is approximately ten feet higher that the lowest point in the excavation.

Dead Creek - Dead Creek serves as a surface water conduit for much of the Sauget and Cahokia area. The creek runs south and southwest through these towns [villages] to an outlet point in the [O]ld Prairie Du Pont [sic] Creek floodway, located south of Cahokia. The floodway in turn discharges to the Cahokia Chute of the Mississippi River. ... Creek Segment A is isolated from the remainder of Dead Creek because the culvert under Queeny Avenue has been blocked with concrete. CS-A drains to an interceptor at the north end of the Cerro property. Water from this interceptor is carried to the Sauget Waste Water Treatment Plant. The culvert is partially blocked a the south end of CS-B, and flow from this Segment to the remainder of the creek is restricted. Although the degree of this restriction has not been evaluated, it is known that water does not usually flow through this culvert."

1.3.5. Geology

Geraghty and Miller (1992) described site geology as follows: "The site(s) is situated on the floodplain of the Mississippi River. The floodplain is locally named the American Bottoms and contains unconsolidated valley fill deposits composed of recent alluvium (Cahokia Alluvium), which overlies glacial material (Henry Formation). Published information indicates that these unconsolidated deposits are underlain by bedrock of

Pennsylvanian and Mississippian age consisting of limestone and dolomite with lesser amounts of sandstone and shale.

The Cahokia Alluvium (recent deposits) consists of unconsolidated, poorly sorted, fine-grained materials with some local sand and clay lenses. These recent alluvium deposits unconformably overlie the Henry Formation which is Wisconsinian glacial outwash in the form of valley train deposits. The Henry Formation is about 100 feet thick. These valley-train materials are generally medium to course sand and gravel and increase in grain size with depth."

1.3.6. Water resources

Domestic water supply. Ecology and Environment (1988) conducted an evaluation of ground water and surface water resources and the results of this evaluation are summarized below.

"The primary source of drinking water for area residents is an intake in the Mississippi River. This intake is located at river mile 181, approximately 3 miles north of the DCP [Dead Creek Project] study area. The drinking water intake is owned and operated by the Illinois American Water Company (IAWC) of East St. Louis, and it serves the majority of residences in the DCP area. IAWC supplies water to ... Sauget .... The Commonfields of Cahokia Public Water District purchases water from IAWC and distributes it to portions of Cahokia and Centerville Township. The Cahokia Water Department also purchases water from IAWC and distributes it to small residential areas in the west and southwest portions of Cahokia.

A review of IDPH and ISGS files indicated that at least 50 area residences [within a 3 mile radius of the site] have wells which are used for drinking water or irrigation purposes. These wells are located in Cahokia (23) ....The nearest private wells to any of the DCP sites are located on Judith Lane, immediately south of the Area 1 sites. Based on interviews with these well owners, only one of the five wells located in this area is used occasionally as a source of drinking water and the other four are never used for this purpose.

In summary, although the majority of residences in the general project area are serviced by public water supply systems, well over 50 homes [within a 3 mile radius of the site] utilize private well supplies for drinking water or irrigation purposes."

Industrial water supply. Ecology and Environment (1988) also described industrial water usage. "Industrial groundwater usage has been very extensive in the past. Peak use occurred in 1962 when groundwater pumpage exceeded 35 million gallons per day (mgd). Relatively few industries utilize well-supplied groundwater for process or cooling water. Total groundwater pumpage from industrial sources in the project area [3 mile radius] is estimated to be less than 0.5 mgd." [Note: Ground water usage is probably even lower today given the decline in the regions industrial base.]

Downstream surface water intakes. Ecology and Environment (1988) indicated that "the nearest downstream surface [water] intake on the Illinois side of the Mississippi River is located at river mile 110, approximately 64 miles south of the project area. This intake supplies drinking water to residents in the Town of Chester and surrounding areas in Randolf County, Illinois. The nearest potentially impacted public water supply on the Missouri side of the river is located at river mile 149, approximately 28 miles south of the DCP area. The Village of Crystal City, Missouri (pop. 4,000) located 28 miles south of the DCP area, utilizes a Ranney well adjacent to the Mississippi River as a source for drinking water. Although this is not actually a surface water intake, it is assumed that the well draws water from the river due to its construction and location adjacent to the river."

Agricultural water supply. Ecology and Environment (1988) reported that "Although agricultural land is found throughout the immediate project area, this land is apparently not irrigated. The nearest irrigated land, other than residential lawns and gardens, is located in the Schmids Lake-East Carondelet area [south of Old Prairie du Pont Creek which is the end of Sauget Area 1]."

1.3.7. Existing fill area information

USEPA Region V, IEPA, Monsanto/Solutia and Cerro Copper have collected a considerable amount of information on soil, ground water, surface water, and sediment in Sauget Area 1. Information included in the January 19, 1999 AOC is given verbatim below. The location of Sites G, H, I, L, M, and N and Creek Segments B, C, D, E, and F are shown on Figure 1 in the Solutia SSP.

Site G. "Located south of Queeny Avenue, east of (and possibly under) the Wiese Engineering facility, and north of a cultivated field in the Village of Sauget. CS-B of Dead Creek is located along the eastern boundary of the Site. This site is approximately 5 acres in size and it was operated and served as a disposal area from approximately 1952 to the late 1980's. The Site was fenced in 1988 pursuant to a U.S. EPA removal action under CERCLA which was funded by potentially responsible parties, including Monsanto. On information and belief, wastes located on the surface and/or in the subsurface of Site G have spontaneously combusted and/or burned for long periods of time on several occasions. U.S. EPA conducted a second CERCLA removal action at Site G in 1995. This removal action involved the excavation of PCB, organics, metals, and dioxin contaminated soils on and surrounding Site G, solidification of open oil pits on the Site, and covering part of the Site (including the excavated contaminated soils) with a clean soil cap approximately 18 to 24 inches thick. Site G is enclosed by a fence and is not currently being used. The property is vegetated.

Site G operated as a landfill from approximately 1952 to 1966. The site was subject to intermittent dumping thereafter until 1988, when the Site was fenced. There is an estimated 60,000 cubic yards of wastes within Site G, including oil pits, drums containing wastes, paper wastes, documents and lab equipment. Soil samples collected from Site G revealed elevated levels of VOCs such as chloroform (11,628 ppb), benzene (45,349 ppb), tetrachloroethene (58,571 ppb), chlorobenzene (538,462 ppb), and total xylenes (41,538 ppb). Soil samples also revealed elevated levels of semi-volatile organic compounds (SVOCs) such as phenol (177,800 ppb), naphthalene (5,428,571 ppb), 2,4,6-trichlorophenol (49,530 ppb), and pentachlorophenol (4,769,231 ppb). Elevated levels of the pesticide 4,4-DDE were detected up to 135,385 ppb. Elevated levels of PCBs were detected at levels as high as 174,419 ppb (Aroclor 1248) and 5,300,000 ppb (Aroclor 1260). Dioxin levels in soils at Site G were detected at levels as high as 44,974 ppb. Metals were detected at elevated concentrations such as arsenic (123 ppm), barium (45,949 ppm), copper (2,215 ppm), lead (3,123 ppm), mercury (34.3 ppm), nickel (399 ppm), and zinc (4,257 ppm). Samples collected from wastes which appeared to be a pure solid product material on Site G revealed PCB levels as high as 3,000,000 ppb and dioxin levels in excess of 50,661 ppb.

Groundwater samples collected from beneath Site G revealed elevated levels of VOCs such as trans-1,2-dichloroethene (200 ppb), 1,2-dichloroethane (480 ppb), trichloroethene (800 ppb), benzene (4,100 ppb), tetrachloroethene -L420 ppb), toluene (7,300 ppb), and ethyl benzene (840 ppb). Elevated levels of SVOCs were detected such as 1,2,4-trichlorobenzene (1,900 ppb), naphthalene (21,000 ppb), 4-chloroaniline (15,000 ppb), and 2,4,6-trichlorophenol (350 ppb). An elevated concentration of PCBs was detected at 890 ppb (Aroclor 1260). Elevated metals in groundwater beneath Site G included arsenic (179 ppb), mercury (2.1 ppb), nickel (349 ppb), zinc (1,910 ppb) and cyanide (350 ppb)."

Site H. "Located south of Queeny Avenue, west of Falling Springs Road and west of the Metro Construction Company property in the Village of Sauget, it occupies approximately 5 to 7 acres of land. The southern boundary of Site H is not known with certainty but it is estimated that the fill area extends approximately 1,250 feet south of Queeny Avenue. Site H is connected to Site I under Queeny Avenue and together they were known to be part of the Sauget-Monsanto Landfill [Note: Sauget used to be known as Monsanto until the name of the village was changed] which operated from approximately 1931 to 1957. Site H is not currently being used and the property is graded and grass-covered with some areas of exposed slag.

Due to the physical connection to Site I, waste disposal at Site H was similar to that at Site I. Chemical wastes were disposed of here from approximately 1931 to 1957. Wastes included drums of solvents, other organics and inorganics, including PCBs, para-nitro-aniline, chlorine, phosphorous pentasulfide, and hydrofluosilic acid. Municipal wastes were also reportedly disposed of at Site H. The estimated volume of wastes in Site H is 110,000 cubic yards. There is no containment beneath Site H. Soil samples collected at Site H revealed elevated levels of VOCs such as benzene (61,290 ppb), tetrachloroethene (5,645 ppb), toluene (76,450 ppb), chlorobenzene (451,613 ppb), ethyl benzene (12,788 ppb), and total xylenes (23,630 ppb). Elevated levels of SVOCs were also found in soil samples such as 1,4-dichlorobenzene (30,645,161 ppb), 1,2 dichlorobenzene (19,354,839 ppb), 1,2,4-trichlorobenzene (7,580,645 ppb), 4-nitroaniline (1,834,000 ppb), phenanthrene (2,114,000 ppb), and fluoranthene (1,330,000 ppb). Soil samples also revealed elevated levels of PCBs such as Aroclor 1260 (18,000,000 ppb), and pesticides 4,4-DDE (780 ppb), 4,4-DDD (431 ppb), and 4,4-DDT (923 ppb). Elevated levels of metals were found such as arsenic (388 ppm), cadmium (294 ppm), copper (2,444 ppm), lead (4,500 ppm), manganese (36,543 ppm), mercury (3.9 ppm), nickel (15,097 ppm), silver (44 ppm), and zinc (39,516 ppm).

Groundwater samples collected from beneath Site H revealed elevated levels of VOCs such as chloroform (3,000 ppb), benzene (4,300 ppb), and toluene (7,300 ppb). Elevated levels of SVOCs were detected in groundwater such as phenol (950 ppb) and pentachlorophenol (650 ppb). An elevated level of PCBs (Aroclor 1260 at 52 ppb) was also detected in groundwater at Site H. Elevated levels of metals were also detected in groundwater such as arsenic (8,490 ppb), copper (2,410 ppb), nickel (17,200 ppb) and cyanide (480 ppb)."

Site I. "Located north of Queeny Avenue, west of Falling Springs Road and south of the Alton & Southern Railroad in the Village of Sauget it occupies approximately 19 acres of land. Segment CS-A of Dead Creek borders Site I on the Site's western side. The site is currently graded and covered with crushed stone and used for equipment and truck parking. Site I was originally used as a sand and gravel pit which received industrial and municipal wastes. Site I is connected to Site H (see below) under Queeny Avenue and together they were known to be part of the "Sauget-Monsanto Landfill." The landfill operated from approximately 1931 to 1957. On information and belief, wastes from Site I leached and/or were released into CS-A and available downstream creek segments until CS-A was remediated in 1990. [Note: The culvert between Creek Segment A and Creek Segment B was blocked in the 1970s.] On information and belief, Site I served as a disposal area for contaminated sediments from historic dredgings of Dead Creek Segment A.

On information and belief, this site accepted chemical wastes from approximately 1931 to the late 1950's. Municipal wastes were also disposed of in Site I. Site I contains approximately 250,000 cubic yards of contaminated wastes and fill material. No subsurface containment is in place beneath Site I. Soil samples collected from Site I have revealed elevated levels of volatile organic compounds (VOCs) such as 1,1,1-trichloroethane (1,692 ppb), trichloroethene (3,810 ppb), benzene (24,130 ppb), tetrachloroethene (5,265 ppb), toluene (77,910 ppb), chlorobenzene (126,900 ppb), ethyl benzene (15,070 ppb), and total xylenes (19,180 ppb). Soil samples also revealed elevated levels of SVOCs such as 1,3-dichlorobenzene (70,140 ppb), 1,4 dichlorobenzene (1,837,000 ppb), 1,2-dichlorobenzene (324,000 ppb), naphthalene (514,500 ppb), and hexachlorobenzene (1,270,000 ppb). Soil samples also revealed elevated levels of polychlorinated biphenyls (PCBs), such as Aroclor 1260 (342,900 ppb), and the pesticides 4,4-DDD (29,694 ppb), 4,4-DDT (4,305 ppb) and

toxaphene (492,800 ppb). Elevated levels of metals were also found in soils, such as beryllium (1,530 ppm), copper (630 ppm), lead (23,333 ppm), zinc (6,329 ppm) and cyanide (3,183 ppm).

Groundwater samples collected from beneath Site I have revealed elevated levels of VOCs such as vinyl chloride (790 ppb), trichloroethene (279 ppb), benzene (1,400 ppb), tetrachloroethene (470 ppb), toluene (740 ppb), and chlorobenzene (3,100 ppb). Elevated levels of SVOCs were also detected in groundwater, such as phenol (1,800 ppb), bis-(2-chloroethoxy)methane (2,900 ppb), 1, 2, 4-trichlorobenzene (2,700 ppb), 4-chloroaniline (9,600 ppb), and pentachlorophenol (2,400 ppb)."

Site L. "Located immediately east of Dead Creek CS-B and south of the Metro Construction Company property in the Village of Sauget. Site L is the former location of two surface impoundments used from approximately 1971 to 1981 for the disposal of wash water from truck cleaning operations. This site is now covered by black cinders and is used for equipment storage. On information and belief, Site L wastes have migrated into Site M (see below).

This site was originally used as a disposal impoundment from approximately 1971 to 1981. The volume of contaminated fill material in Site L is not known, however, the area of the impoundment is estimated to be 7,600 square feet. There is no known containment of wastes beneath Site L. Soil samples collected at Site L revealed elevated levels of VOCs such as chloroform (20,253 ppb), benzene (4,177 ppb), and toluene (26,582 ppb). Elevated levels of SVOCs were also detected such as 2-chlorophenol (2,152 ppb), pentachlorophenol (58,228 ppb), and di-n-butyl phthalate (2,784 ppb). Total PCBs were found at a level of 500 ppm in soils. Elevated levels of metals were detected such as antimony (32 ppm), arsenic (172 ppm), and nickel (2,392 ppm).

Groundwater samples collected from beneath Site L revealed elevated levels of VOCs such as chloroform (730 ppb) and benzene (150 ppb). SVOCs were also detected in groundwater such as phenol (150 ppb), 2-chlorophenol (130 ppb)., 4-methyl phenol (75 ppb), 2-nitrophenol (41 ppb), and 4-chloroaniline (60 ppb). Elevated levels of metals in groundwater included arsenic (14,000 ppb), cadmium (32 ppb) and zinc (2,210 ppb)."

Site M. "Located along the eastern side of Dead Creek CS-B (south of Site L) at the western end of Walnut Street in the Village of Cahokia. Site M was originally used as a sand borrow pit (dimensions = 220 feet by 320 feet) in the mid to late 1940's. The pit is hydrologically connected to Dead Creek through an eight-foot opening at the southwest portion of the pit. On

information and belief, wastes from CS-B have in the past and potentially continue to migrate into Site M via this connection. The site is currently fenced.

Site M was originally constructed as a sand borrow pit in the mid to late 1940's. This pit is approximately 59,200 square feet in size and previous investigations indicate that approximately 3,600 cubic yards of contaminated sediments are contained within the pit. It is estimated that the pit is approximately 14 feet deep and it is probable that there is a hydraulic connection between this pit water and the underlying groundwater. Surface water samples collected from Site M revealed elevated levels of VOCs such as chloroform (27 ppb), toluene (19 ppb) and chlorobenzene (33 ppb). SVOCs detected in surface water included phenol (28 ppb), 2-chlorophenol (14 ppb), 2,4-dimethyl phenol (13 ppb), 2,4-dichlorophenol (150 ppb), and pentachlorophenol (120 ppb). Pesticides detected in surface water include dieldrin (0.18 ppb), endosulfan II (.06 ppb), 4,4-DDT (0.24 ppb), 2,4-D (47 ppb) and 2,4,5-TP (Silvex) (3.4 ppb). PCBs were also detected in surface water at a maximum level of 0.0044 ppb

Sediment samples collected from Site M revealed elevated levels of VOCs such as 2-butanone (14,000 ppb), chlorobenzene (10 ppb) and ethyl benzene (0.82 ppb). SVOCs detected in sediments included 1,4-dichlorobenzene (40 ppm), 1,2-dichlorobenzene (26 ppm), 1,2,4-trichlorobenzene (14 ppm), pyrene (27 ppm), fluoranthene (21 ppm), chrysene (12 ppm), and benzo(b)fluoranthene (15 ppm). Total PCB levels were detected as high as 1,100 ppm. Elevated levels of metals were also detected in sediments at Site M, including antimony (41.2 ppm), barium (9,060 ppm), cadmium (47.2 ppm), copper (21,000 ppm), nickel (2,490 ppm), silver (26 ppm), zinc (31,600 ppm), lead (1,910 ppm), arsenic (94 ppm) and cyanide (1.3 ppm)."

Site N. "Located along the eastern side of Dead Creek CS-C, south of Judith Lane and north of Cahokia Street in the Village of Cahokia. This Site encompasses approximately 4 to 5 acres of previously excavated land used to dispose of concrete rubble and demolition debris. The excavation began in the 1940's and the site is currently inactive and fenced.

Initially developed as a borrow pit in the 1940's, this Site has been filled with concrete rubble, scrap wood and other demolition debris. The depth

of the fill may be as much as 30 feet and it occupies approximately 4 to 5 acres of land. Soil samples collected from Site N revealed the presence of SVOCs such as phenanthrene (434 ppb), fluoranthene (684 ppb), and pyrene (553 ppb). An elevated level of mercury (9 ppm) was also detected in soil at Site N."

1.3.8. Existing Dead Creek information

"Dead Creek stretches from the Alton & Southern Railroad at its northern end and flows south through Sauget and Cahokia for approximately 3.5 miles before emptying into the Old Prairie du Pont Creek, which flows approximately 2,000 feet west into a branch of the Mississippi River known as the Cahokia Chute. For many years, Dead Creek has been a repository for local area wastes. On December 21, 1928, an easement agreement between local property owners and representatives of local business, municipal and property interests was executed to "improve the drainage in that District (Dead Creek) by improving Dead Creek so as to make it suitable for the disposal of wastewater, industrial waste, seepage and storm water." Thereafter, Dead Creek systematically received direct and indirect discharges from local businesses and from the Village for many ears to come. Dead Creek temporarily passes through corrugated pipe at the southern end of CS-E.

Creek Segment CS-A is the northernmost segment of the creek. It is approximately 1800 feet long and 100 feet wide, running from the Alton & Southern Railroad to Queeny Avenue. This segment of the creek originally consisted of two holding ponds which were periodically dredged. For several years, CS-A and available downstream segments (*e.g.*, ones that were not blocked off) received direct wastewater discharges from industrial sources and served as a surcharge basin for the Village of Sauget (formerly the Village of Monsanto) municipal sewer collection system. When the system became backed up or overflowed, untreated wastes from industrial users of the sewer system were discharged directly into CS-A. On several occaisions, CS-A was dredged and contaminated sediments were disposed of onto adjacent Site I. In 1968, the Queeny Avenue culvert, which allowed creek water to pass from CS-A to CS-B, was permanently blocked by the Village of Sauget.

Remediation work was conducted by Cerro Copper in CS-A in 1990. Approximately 27,500 tons of contaminated sediments were removed to RCRA and TSCA permitted facilities. CS-A is now filled and covered with crushed gravel. Land use surrounding CS-A is industrial.

Creek Segment CS-B extends for approximately 1800 feet from Queeny Avenue to Judith Lane. Sites G, L, and M border this creek segment. Land use surrounding CS-B is primarily commercial with a small residential area near the southern end of this segment. Agricultural land lies to the west of the creek and south of Site G. In 1965, the Judith Lane culvert, which allowed creek water to pass from CS-B to CS-C, was blocked. CS-B is hydrologically connected to Site M by a man-made ditch (see above).

Creek Segment CS-C extends for approximately 1300 feet from Judith Lane south to Cahokia Street. Site N borders this creek segment. Land use is primarily residential along both sides of CS-C.

Creek Segment CS-D extends for approximately 1100 feet from Cahokia Street to Jerome Lane. Land use is primarily residential along both sides of CS-D.

Creek Segment CS-E extends approximately 4300 feet from Jerome Lane to the intersection of Illinois Route 3 and Route 157. Land use surrounding CS-E is predominantly commercial with some mixed residential use. Dead Creek temporarily passes through corrugated pipe at the southern end of CS-E.

Creek Segment CS-F is approximately 6500 ft long and extends from Route 157 to the Old Prairie du Pont Creek. CS-F is the widest segment of Dead Creek, and a large wetland area extends several hundred feet out from both sides of the creek.

Information on the types of wastes disposed of and the types and levels of contamination found at the Sauget Area 1 Site have been provided to USEPA Region V from various sources, including, but not exclusively from: 1) CERCLA 103(c) Submittals; 2) CERCLA 104(e) Responses; 3) Expanded Site Investigation Dead Creek Project Sites (Ecology and Environment, 1988); 4) Removal Action Plan for Dead Creek Sites (Weston-SPER, 1987); 5) Description of Current Situation at the Dead Creek Project Sites (Ecology and Environment, 1986); 6) Site Investigations for Dead Creek Segment B and Sites L and M (Geraghty & Miller, Inc. 1992); 7) Site Investigation/Feasibility Study for Creek Segment A (Advent Group, 1990); 8) Preliminary Ecological Risk Assessment for Sauget Area 1, Creek Segment F (Ecology and

Environment, 1997); 9) EPA Removal Action Report for Site G (Ecology and Environment 1994); 10) Area One Screening Site Inspection Report; and 11) Site Investigation Feasibility Study for Creek Segment A (Advent Group 1990)."

Creek Segment A. "Approximately 20,000 cubic yards of contaminated material were removed from this segment of Dead Creek in 1990, and the area was then backfilled with clean material. The assumption that only low-levels of residual contamination may currently exist within CS-A is yet to be confirmed. Prior to remediation activities, soil and sediment samples collected from CS-A revealed elevated levels of VOCs such as 1,2-dichloroethene (15,000 ppb), trichloroethene (100,000 ppb), tetrachloroethene (11,000 ppb), chlorobenzene (31,000 ppb), ethyl benzene (80,000 ppb), and xylene (500,000 ppb). Elevated levels of SVOCs detected in soils and sediments included 1,3-dichlorobenzene, 4-chloroaniline (17,000 ppb), acetophenone (24,000 ppb), 1, 2, 4, 5-tetrachlorobenzene (28,000 ppb), pentachlorobenzene (37,000 ppb), phenathrene (14,000 ppb), and pyrene (10,000 ppb). Elevated levels of PCBs (total) were also detected at a maximum concentration of 3,145,000 ppb. Elevated levels of metals were also detected in soils and sediments in CS-A including silver (348 ppm), arsenic (194 ppm), cadmium (532 ppm), copper (91,800 ppm), mercury (124 ppm), nickel (6,940 ppm), lead (32,400 ppm), antimony (356 ppm), selenium (41.6 ppm), and zinc (26,800 ppm)."

Creek Segment B. "Elevated levels of VOCs and SVOCs were detected in sediment samples collected from CS-B such as benzene (87 ppb), toluene (810 ppb), chlorobenzene-(5,200 ppb), ethyl benzene (3,600 ppb), trichlorobenzene (3,700 ppm), dichlorobenzene (12,000 ppm), chloronitrobenzene (240 ppm), xylenes (540 ppm), 1,4-dichlorobenzene (220,000 ppb), 1,2-dichlorobenzene (17,000 ppb), phenanthrene (15,000 ppb), fluoranthene (11,000 ppb), pyrene (13,000 ppb). Elevated levels of PCBs exist within CS-B at levels as high as 10,000 ppm. Elevated levels of metals were also detected in sediments in CS-B including arsenic (6,000 ppm), cadmium (400 ppm), copper (44,800 ppm), lead (24,000 ppm), mercury (30 ppm), nickel (3,500 ppm), silver (100 ppm), and zinc (71,000 ppm).

Surface water samples collected from CS-B revealed elevated concentrations of VOCs such as chloroform (27 ppb), 1,1-dichloroethene (3 ppb), toluene (20 ppb), and chlorobenzene (33 ppb). SVOCs detected in surface water included phenol (28 ppb), 2-chlorophenol (14 ppb), 1,4-dichlorobenzene, 2-methyl phenol (4 ppb), 4-methyl phenol (35 ppb), 2,4-dichlorophenol (150 ppb), naphthalene (8 ppb), 3-nitroaniline (9 ppb), and pentachlorophenol (120 ppb). Pesticides were also detected in surface water samples including dieldrin (0.18 ppb), 4,4-DDT (0.24 ppb), 2,4-D

(47 ppb) and Silvex (3.4 ppb). An elevated level of PCBs (aroclor 1260) was also detected in the surface water of CS-B at a level of 44 ppb. Elevated levels of metals were detected in surface water such as aluminum (9,080 ppb), barium (7,130 ppb), arsenic (31 ppb), cadmium (25 ppb), chromium (99 ppb), copper (17,900 ppb), lead (1,300 ppb), mercury (8.6 ppb), nickel (1,500 ppb), and zinc (10,300 ppb)."

Creek Segment C. "Elevated levels of VOCs and SVOCs were detected in sediments in this segment of Dead Creek including fluoranthene (4,600 ppb), pyrene (4,500 ppb), benzo(a)anthracene (3,300 ppb), chrysene (4,400 ppb), benzo(b)fluoranthene (7,500 ppb), benzo(a)pyrene (4,500 ppb), indeno(1,2,3-cd)pyrene (4,300 ppb), benzo(g, h, l) perylene (1,500 ppb), dibenzo(a, h)anthracene (4,000 ppb), and 4-methyl-2-pentanone (1,200 ppb). PCBs (total) were also detected in sediments from CS-C at a maximum concentration of 27,500 ppb. Sediment samples also revealed elevated levels of metals such as copper (17,200 ppm), lead (1,300 ppm), nickel (2,300 ppm), zinc (21,000 ppm) and mercury (2.81 ppm).

Surface water samples collected from creek segment CS-C revealed elevated levels of metals such as lead (710 ppb), mercury (1.9 ppb), and nickel (83 ppb)."

Creek Segment D. "Elevated concentrations of VOCs and SVOCs were detected in sediment samples collected from CS-D including 4-methyl-2-pentanone (1,200 ppb), benzo(b)fluoranthene (500 ppb), indeno(1, 2, 3-cd)pyrene (310 ppb), and dibenzo(a, h)anthracene (360 ppb). PCBs (total) were detected in sediments at a maximum concentration of 12,000 ppb. Elevated concentrations of metals were also detected such as cadmium (42 ppm), copper (1,630 ppm), lead (480 ppm), mercury (1 ppm), and zinc (6,590 ppm).

Surface water samples collected from CS-D revealed elevated concentrations of metals such as cadmium (8.1 ppb), lead (89 ppb), and nickel (189 ppb)."

Creek Segment E. "Elevated concentrations of VOCs and SVOCs were detected in sediment samples collected from CS-E including chlorobenzene (120 ppb), pyrene (5,300 ppb), benzo(b)fluoranthene (2,400 ppb), and chrysene (2,800 ppb). Elevated levels of PCBs (total) were also detected at a maximum concentration of 59,926 ppb. Elevated levels of metals were

also detected in the sediments of CS-E including cadmium (23.1 ppm), copper (8,540 ppm), lead (1,270 ppm), mercury (1.53 ppm), nickel (2,130 ppm), and zinc (9,970 ppm)."

Creek Segment F. "Elevated concentrations of VOCs and SVOCs were detected in the sediments of CS-F such as toluene (29 ppb), 4-methyl phenol (1,100 ppb), fluoranthene (310 ppb), and pyrene (340 ppb). Pesticides were also detected in the sediments such as 4,4-DDE (97 ppb), endrin (66 ppb), endosulfan 11 (203 ppb), and methoxychlor (8 ppb). PCBs (total) were also detected in sediments at a maximum concentration of 5,348 ppb. Elevated levels of metals were also detected in the sediments such as arsenic (276 ppm), lead (199 ppm), mercury (0.55 ppm), cadmium (23.5 ppm), copper (520 ppm), nickel (772 ppm) and zinc (4,520 ppm). Elevated concentrations of dioxins were also detected in sediments in CS-F at a maximum concentration of 211 picograms per gram."

1.3.9. Existing data

In 1998, Ecology and Environment prepared a report (Sauget Area 1 Data Tables/Maps) for USEPA Region V that "summarized existing technical and potentially responsible party (PRP) data for each subunit of the sites along with other information compiled during E & E's file searches of various agencies and organizations." This report contains the following information obtained from work done by Illinois Environmental Protection Agency (IEPA), Ecology and Environment (E&E), Weston, Geraghty & Miller (G&M), and The Advent Group.

Volume 1 - Sauget Area 1

Introduction
Report Organization
Site G
- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - Organics and Metals (IEPA, 1984)
  - Surface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1986)
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)
  - Soil Samples - PCB and PCP (Weston, 1987)
  - Waste/Soil Samples - Metals and Organics (IEPA, 1984)
  - Soil Samples - VOCs (G&M, 1991)
  - Soil Samples - BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Soil Samples - VOCs, BNAs, Pesticides/PCBs (IEPA, 1994)

Site H
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)

Site L
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)
  - Soil Samples - PCBs (IEPA, 1981)
  - Sediment Samples - VOCs, BNAs, PCBs, Metals (G&M, 1991)
  - Subsurface Soil Samples - TCLP Metals, VOCs, BNAs, Pesticides/PCBs (G&M, 1991)

Site I
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)

Creek Segment A
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)
  - Sediment Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Surface Water Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1986)
  - Soil Samples - PCBs, Metals (IEPA, 1981)
  - Sediment Samples - Metals and Organics (IEPA, 1981)
  - Surface Water Samples - Metals and Organics (IEPA, 1981)
  - Soil/Sediment Samples - VOCs, BNAs, PCBs, PCB Precursors, Metals (Advent Group, 1990)

Site M
- Site Narrative
- Analytical Data Summaries
  - Surface Water Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Sediment Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1986)

- Sediment/Surface Water Samples - VOCs, BNAs, Metals, PCBs, RCRA Hazardous Characteristic Parameters (G&M, 1992)
- Water/Sediment Samples - Metals and Organics (IEPA, 1980)
- Surface Water Samples - VOCs, BNAs, Pesticides/PCBs, Metals, Herbicides (IEPA, 1994)
- Soil/Sediment Samples - Metals (IEPA, 1980)

Creek Segment B
- Site Narrative
- Analytical Data Summaries
  - Sediment Soil Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Surface Water Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Sediment Samples - BNAs, VOCs, Metals (G&M, 1991)
  - Soil/Sediment Samples - Metals, Pesticides/PCBs, VOCs, BNAs (G&M, 1991)
  - Sediment Samples - RCRA Hazardous Characteristic Parameters (G&M, 1991)
  - Soil Sediment Samples - Organics, Phosphorus, Metals (IEPA/Monsanto, 1980)
  - Surface Water Sample - Metals (Eastep, 1975)
  - Surface Water Samples - VOCs, BNAs, Metals, Pesticides/PCBs (IEPA, 1993/94)
  - Soil/Sediment Samples - Metals, Organics (IEPA, Sept. 1980)
  - Soil/Sediment Samples - Metals, Organics (IEPA, Oct. 1980)

Site N
- Site Narrative
- Analytical Data Summaries
  - Subsurface Soil Samples - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1986)

Creek Segment C
- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Surface Water Samples - VOCs, BNAs, Pesticides/PCBs, Metals, (E&E, 1986)
  - Sediment/Soil Samples - Metals and Organics (IEPA, 1980)
  - Water Samples - Metals and Organics (IEPA, 1980)
  - Soil Samples - Metals and Organics (IEPA, 1991)
  - Sediment Samples - Metals (IEPA, 1980)
  - Surface Water Samples - VOCs, BNAs, Metals, Pesticides/PCBs (IEPA, 1993)
  - Water Samples - Metals (IEPA, 1980)

Creek Segment D

- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1986)
  - Surface Water Samples - VOCs, BNAs, Pesticides/PCBs, Metals, (E&E, 1986)
  - Sediment Samples - VOCs, SVOCS, Pesticides/PCBs, Inorganics, Metals (IEPA, 1991)

Creek Segment E
- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - VOCs, SVOCS, Pesticides/PCBs, Inorganics, Metals (IEPA, 1991)
  - Sediment Samples - Metals and Organics (IEPA, 1980)
  - Water Samples - Metals and Organics (IEPA, 1980)
  - Sediment Samples - Metals (IEPA, 1980)
  - Water Samples - Metals (IEPA, 1980)

Creek Segment F
- Site Narrative
- Analytical Data Summaries
  - Sediment Samples - Metals, PCBs (E&E, 1997)
  - Soil/Sediment Samples - VOCs, SVOCs, Pesticides/PCBs (IEPA, 1991)
  - Sediment Samples - VOCs, SVOCs, Pesticides/PCBs, Inorganics, Metals (IEPA, 1991)
  - Soil/Sediment Samples - Metals and Organics (IEPA, 1990)

Area 1 Groundwater
- Site Narrative
- Creek Segment B - Metals/Indicators (IEPA, 1980)
- Site G - VOCs, BNAs, Metals (E&E, 1987)
- Site H - VOCs, BNAs, Pesticides/PCBs, Metals (E&E, 1987)
- Site I - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1987)
- Site L - VOCs, BNAs, Metals, Pesticides/PCBs (E&E, 1987)
- Private Wells - VOCs, BNAs, Pesticide/PCBs, Metals (E&E, 1987)
- Groundwater Monitoring Survey - Organics and Metals (IEPA, 1982)
- Monitoring Well Samples - Metals, Pesticides/PCBs (IEPA, 1980 and 1983)
- Groundwater Samples - VOCs, SVOCs, Pesticides/PCBs, Inorganics (IEPA, 1991)
- Water Samples - PCBs (IEPA and Monsanto, 1980)

Groundwater Samples - Metals and Organics (IEPA, 1981)
Groundwater Samples - Metals and Organics (IEPA, 1981)
Groundwater Samples - VOCs, SVOCs, Pesticides/PCBs, Metals (IEPA, 1991)

The 1998 Ecology and Environment Sauget Area 1 Data Tables/Maps Report is not included in the SSP at the request of the Agency. A summary of this information will be included in the SSP Data Report.

1.3.10. Existing risk assessments

In 1997 Ecology and Environment prepared the report "Preliminary Ecological Risk Assessment for Sauget Area 1, Creek Segment F, Sauget, St. Clair County, Illinois". Ecology and Environment "was tasked by the United States Environmental Protection Agency (U.S. EPA) to prepare a screening-level ecological risk assessment for the Sauget Area 1, Creek Segment F site ... The objective of this report is to determine whether the site poses no immediate or long-term ecological risk, or if a potential ecological risk exists and further evaluation is necessary."

Conclusions and recommendations of the report are given below:

"Based on this investigation, site contamination does not appear to threaten human health. Sediment contamination levels are below risk-based values and few people enter the site boundaries.

Elevated levels of metals and PCBs may be highly detrimental to the ecology of this site [Creek Segment F]. The presence of arsenic, cadmium, and dioxin greater than SEL guidelines may decrease the species richness of the area. Sensitive species, including the endangered Black-Crowned Night Heron, inhabit the site and therefore, are subject to effects such as acute toxicity, reduced growth, inhibited reproduction, and other adverse effects. Finally, species that feed on contaminated organisms may bioaccumulate the contaminants and become adversely affected.

The contamination on the site [Creek Segment F] warrants further investigation and possible remediation, especially because it provides high quality wetland habitat."

This report is included in the SSP as Appendix A.

1.4. Current status

The current status of this project is described in the AOC and its associated Scope of Work (SOW).

1.5. Project objectives

The purpose of the SSP is to gather sufficient information from the Sauget Area 1 Site to identify the nature of waste materials in Sites G, H, I, L, M, and N and to assess the extent of constituent migration in soil, ground water, surface water, sediments, and air at the site.

Collected data will be used by others to prepare a Human Health Risk Assessment (HHRA), an Ecological Risk Assessment (ERA), and an EE/CA for soil, surface water, sediments, and air; and an RI/FS for ground water. The SSP and Field Sampling Plan (FSP) (O'Brien & Gere Engineers, Inc., 1999), include a description of the sample media, sample locations, number of samples, and analytical methods.

The main components of the SSP addressed in this QAPP include:

- Source area sampling (soil gas sampling, waste sampling, buried drum and tank identification)
- Ground water sampling (upgradient, fill areas, downgradient alluvial aquifer, bedrock, domestic wells, slug tests, and grain size analysis)
- Soil sampling (undeveloped areas, developed areas, and background)
- Sediment sampling (undeveloped areas, developed areas, Borrow Pit Lake, and Dead Creek)
- Surface water sampling
- Air sampling
- Pilot test sampling.

Table 1 lists sampling efforts, objectives, analyses, data uses, and analytical levels for this project. Specific analytical methods are listed in Table 2. Specific numbers of samples, frequency of QC samples, and types of analyses are listed in Table 3. Tables 4A and 4B list the laboratory standard operating procedure and quality assurance manual of Savannah

Laboratories and Environmental Services, Inc. and Triangle Laboratories, Inc., respectively, which are used for monitoring activities. The remainder of this QAPP describes the specific approaches that will be taken to achieve the required Data Quality Objectives (DQOs).

1.5.1. Project target parameter and intended data usages

The list of target parameters for this project is included in Tables 5A through 5P.

1.5.2. Data quality objectives and criteria for measurement data

The Data Quality Objective (DQO) Process is a series of planning steps based on the Scientific Method that is designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended application. The DQO process is presented in *Guidance for the Data Quality Objectives Process*, USEPA QA/G-4 (USEPA, 1994a). DQOs are quantitative and qualitative statements derived from outputs of each step of the DQO process that:

- Clarify the study objective
- Define the most appropriate type of data to collect
- Determine the most appropriate conditions from which to collect the data.

The DQO process is developed through a multi-step process that includes the following:
Step 1. State the problem to be resolved.
Step 2. Identify the decision to be made.
Step 3. Identify the inputs to the decision.
Step 4. Define the boundaries of the study.
Step 5. Develop a decision rule.
Step 6. Specify the tolerable limits on decision errors.
Step 7. Optimize the design for obtaining the data.

The DQOs are then used to develop a scientific and resource-effective sampling design. The DQO process allows decision makers to define their data requirements and acceptable levels of decision during planning before data are collected.

The DQOs developed for fill area waste, ground water, soil, sediment, surface water, and air samples were used to develop a scientific and resource-effective sampling design and were based on the seven step

process. The following sections describe the process used to develop the DQOs for each sample matrix type.

Fill area waste:
Step 1: State the problem - a description of the problem and specifications of available resources and relevant deadlines for the study.

1. *Identify the members of the planning teams* - The members of the planning team will include the Solutia Remedial Project Manager, the ENSR Risk Assessor, the O'Brien & Gere Project Officer, the O'Brien & Gere Project Manager, the O'Brien & Gere Quality Assurance Officer, the O'Brien & Gere Field Leader, and the Savannah Laboratories Project Manager.

2. *Identify the primary decision maker* - There will be no primary decision maker; decisions will be made by consensus.

3. *Develop a concise description of the problem* - At Sauget Area 1, the fill areas are identified as Sites G, H, I, L, M, and N. Constituents in the fill areas may leach to the underlying ground water. Four soil borings will be installed at Sites G, H, I, L, and N, and continuous soil samples will be collected from grade to 2 ft below the bottom of the fill material which is assumed to be 40 ft below grade. A discrete surface soil sample, from 0 to 0.5 ft, will also be collected at the location of the four soil borings at Sites G, H, I, L, and N. The surface soil samples analyzed will be used in the Human Health Risk Assessment (Volume 1B). Color digital photographs of each soil sample will be taken against a scale to provide a record of materials present in each fill area (Sites G, H, I, L, and N).

   One composite waste sample will be collected at each boring location and analyzed for the waste disposal characteristics listed in Table 1. One discrete surface soil sample will be collected at each boring location and analyzed as listed in Table 1. Site M will be characterized by collecting four sediment samples.

   Existing information (*e.g.*, the 1988 Ecology and Environment report and the results of the aerial photograph analysis, soil gas surveys, and magnetometer surveys conducted as part of the SSP) will be used to select boring locations.

4. *Specify available resources and relevant deadlines for the study* - Solutia will provide the resources needed to meet the stated objectives. The project schedule is presented in Volume 1A, Section 16.0 of the SSP.

Step 2: Identify the decision - a statement of the decision that will use environmental data and the actions that could result from this decision.

1. *Identify the principal study decision* - What is the nature and extent of the waste materials in the fill areas at the site?

2. *Define alternative actions that could result from resolution of the principle study question* -

   a. Waste materials are identified at the site, resulting in development of a site-specific risk assessment to develop remediation goals.

   b. Waste materials are not identified, resulting in no further action.

3. *Combine the principle study question and the alternative actions into a decision statement* - Determine the nature and extent of the waste materials in the fill areas at the site and develop a site-specific risk assessment to develop remediation goals.

4. *Organize multiple decisions* - Only one decision is being evaluated.

Step 3: Identify inputs to the decision - a list of environmental variables or characteristics that will be measured and other information needed to resolve the decision statement.

1. *Identify the information that will be required to resolve the decision statement* - To resolve the decision statement, the planning team needs to obtain measurements of contaminants, including ignitability, corrosivity, reactivity, VOCs, SVOCs, metals, mercury, cyanide, PCBs, pesticides, herbicides, dioxin, and dibenzofuran concentrations, presented in Table 1, at the site.

2. *Determine the sources for each item of the information identified* - The waste materials will be tested using the methods listed in Table 2.

3. *Identify the information that is needed to establish the action level* - Four soil borings will be installed at Sites G, H, I, L, and N, and continuous soil samples will be collected from grade to 2 ft below the bottom of the fill material, which is assumed to be 40 ft below grade. A discrete surface soil sample, from 0 to 0.5 ft, will also be collected at

the location of the four soil borings at Sites G, H, I, L, and N. The surface soil samples analyzed will be used in the Human Health Risk Assessment (Volume 1B). Color digital photographs of each soil sample will be taken against a scale to provide a record of materials present in each fill area (Sites G, H, I, L, and N).

One composite waste sample will be collected at each boring location and analyzed for the waste disposal characteristics listed in Table 1. One discrete surface soil sample will be collected at each boring location and analyzed as listed in Table 1. Site M will be characterized by collecting four sediment samples.

Existing information (*e.g.*, the 1988 Ecology and Environment report and the results of the aerial photograph analysis, soil gas surveys, and magnetometer surveys conducted as part of the SSP) will be used to select boring locations. Constituents of concern (COCs) will be identified in the risk assessment and remedial goals will be developed for the COCs based on exposure pathways evaluated in the risk assessment.

4. *Confirm the appropriate measurement methods exist to provide the necessary data* - Ignitability, corrosivity, reactivity, VOCs, SVOCs, metals, mercury, cyanide, PCBs, pesticides, herbicides, dioxin, and dibenzofuran concentrations can be measured using the USEPA methods listed in Table 2. The laboratory detection limits for the ignitability, corrosivity, reactivity, VOCs, SVOCs, metals, mercury, cyanide, PCBs, pesticides, herbicides, dioxin, and dibenzofuran are listed in Tables 5A through 5P.

Step 4: Define the boundaries of the study - a detailed description of the spatial and temporal boundaries of the problem, characteristics that define the population of interest, and any practical considerations of interest.

1. *Specify the characteristics that define the population of interest* - Waste material samples will be collected at fill area Sites G, H, I, L, and N.

2. *Define the spatial boundary of the decision statement* -

a. *Define the geographic area to which the decision statement applies* - Decisions will apply to the waste materials in fill area Sites G, H, I, L, and N.

b. *When appropriate divide the population into strata that have relatively homogenous characteristics* - Waste material samples are divided into the following categories: Sites G, H, I, L, and N.

3. *Define the temporal boundary of the decision statement* -

a. *Determine the time frame to which the decision statement applies* - It will be assumed that the sampling data will represent current concentrations within the fill areas.

b. *Determine when to collect the data* - Fill area waste material samples will be collected during one sampling round and analyzed for ignitability, corrosivity, reactivity, VOCs, SVOCs, metals, mercury, cyanide, PCBs, pesticides, herbicides, dioxin, and dibenzofuran constituents associated with the analytical methods listed in the FSP.

4. *Define the scale of decision making* - The scale of decision making will be from the extraction site for the one waste material sampling round.

5. *Identify practical constraints on data collection* - The most important practical constraint that could interfere with the study is interference in the ability to collect waste material samples in the field due to inclement weather.

Step 5: Develop a decision rule - to define the parameter of interest, specify the action level and integrate previous DQO outputs into a single statement that describes a logical basis for choosing among alternative actions.

1. *Specify the statistical parameter that characterizes the population of interest* - The laboratory results from the one sampling event will characterize the population of interest. A statistical parameter is not being used because only one sampling event is scheduled; the small sample size would not result in meaningful sample statistics.

2. *Specify the action level for the study* - Preliminary remediation goals will be developed based on readily available information, such as chemical- specific applicable or relevant and appropriate requirements (ARARs), or other reliable information. Preliminary remediation goals will be modified, as necessary, as more information becomes available

during the Remedial Investigation/Feasibility Study (RI/FS). Final remediation goals will be determined when the remedy is selected. Remediation goals will establish acceptable exposure levels that are protective of human health and the environment.

3. *Develop a decision rule* -

   a. If ignitability, corrosivity, reactivity, VOCs, SVOCs, metals, mercury, cyanide, PCBs, pesticides, herbicides, dioxin, and dibenzofuran concentrations exceed preliminary remediation goals, use site-specific risk assessment to develop remediation goals and complete the Engineering Evaluation/Cost Analysis (EE/CA) and RI/FS reports.

   b. If ignitability, corrosivity, reactivity, VOCs, SVOCs, metals, mercury, cyanide, PCBs, pesticides, herbicides, dioxin, and dibenzofuran concentrations do not exceed preliminary remediation goals, no additional action is needed.

Step 6: Specify tolerable limits on decision errors - the decision maker's tolerable decision error rates based on a consideration of the consequences of making a decision error.

1. *Determine the possible range of the parameter of interest* - The range of the expected constituents varies. The laboratory analysis will screen samples and adjust for the concentration ranges during the analysis process.

2. *Identify the decision errors and choose the null hypothesis* -

   a. *Define both types of decision errors and establish the true state of nature for each decision error.* The planning team has determined that the two decision errors are, (I) deciding that the nature and extent of fill area contamination is not already defined when it truly is; and, (II) deciding that the nature and extent of fill area contamination is defined when it truly is not.

      - The true state of nature for the decision error (I) is that the nature and extent of fill area contamination is defined.

- The true state of nature for the decision error (II) is that the nature and extent of fill area contamination is not defined.

b. *Specify and evaluate the potential consequences of each decision error* - The consequences of deciding that the nature and extent of fill area contamination is not defined when it truly is will be that incorrect information is used in the risk assessment to develop remediation goals.

   The consequences of deciding that the nature and extent of fill area contamination is defined when it truly is not will be that migration of fill area ground water may pose a threat to off-site drinking water supplies.

c. *Establish which decision error has more severe consequences of each decision error* - The planning team has concluded that the decision error (II) has more severe consequences near the action level because the risk of jeopardizing human health outweighs the consequences of having incorrect information for risk assessment and remediation goal development.

d. *Define the null hypothesis (baseline condition) and the alternative hypothesis and assign the terms "false positive" and "false negative" to the appropriate decision error* - The baseline condition or null hypothesis is "the nature of fill area contamination is not defined."

   The alternative hypothesis is "the nature of fill area contamination is defined."

   The false positive decision error occurs when the null hypothesis is rejected when it is true.

   The false negative decision error occurs when the null hypothesis is not rejected when it is true.

3. *Specify the range of possible values of the parameters of interest where the consequences of decision errors are relatively minor (grey area)* - In this case, because the sample size is small, statistical methods cannot be used for data collection designs. Therefore, in order to avoid false negative decision errors, qualitative guidelines will be established.

4. *Assign probability values to points above and below the action level that reflect the tolerable probability for the occurrence of decision errors* - Not applicable to the data collection design.

Step 7: Optimize the plan

1. *Review the DQO outputs and existing environmental data* - In 1998, Ecology and Environment prepared a report (Sauget Area 1 Data Tables/Maps) for USEPA Region V that "summarized existing technical and PRP data for each subunit of the sites along with other information compiled during Ecology and Environment's file searches of various agencies and organizations." This report contains information obtained from work done by IEPA, E&E, Weston, G&M, and The Advent Group. Fill area constituent data is included in the January 19, 1999 AOC and summarized in section 1.1.7 of the FSP.

2. *Develop the general data collection design* - The data collection design will involve one fill area sampling round. QC samples will be collected as described on Table 3 of this QAPP. Following review of the results of the sampling round, a decision will be made to either reject the null hypothesis, or accept the null hypothesis.

Ground water.

Step 1: State the problem- a description of the problem and specifications of available resources and relevant deadlines for the study.

1. *Identify the members of the planning team* - The members of the planning team will include the Solutia Remedial Project Manager, the ENSR Risk Assessor, the O'Brien & Gere Project Officer, the O'Brien & Gere Project Manager, the O'Brien & Gere Quality Assurance Officer, the O'Brien & Gere Field Leader, and the Savannah Laboratories Project Manager.

2. *Identify the primary decision maker* - There will be no primary decision maker; decisions will be made by consensus.

3. *Develop a concise description of the problem* - At Sauget Area 1, the fill areas are identified as Sites G, H, I, L, M, and N. Ecology and Environment (1998) defined the areal extent of VOCs and SVOCs in shallow ground water at Sites G, H, I, and L. These plumes have migrated several hundred feet downgradient from disposal sites that were used from the 1930s to the 1970s. Plume shape indicates VOC and SVOC migration toward the Mississippi River, which is the

discharge point for the American Bottoms aquifer. Ecology and Environment did not collect information on COC distribution in the intermediate and deep portions of the aquifer. Constituents in the fill areas may leach to the underlying ground water. VOCs in ground water may volatilize into outdoor air and may infiltrate into air in overlying buildings. Constituents in ground water may discharge to Dead Creek and subsequently be transported downstream to the lower reaches of Dead Creek and into Borrow Pit Lake.

Ground water samples will be collected in the alluvial aquifer and bedrock at the fill areas, in the alluvial aquifer downgradient of the fill areas, and in shallow ground water and domestic wells adjacent to Dead Creek. The purpose of this sampling is to define current ground water quality conditions at the source areas, to define the extent of migration away from the source areas, and to provide information for the human health risk assessment (construction/utility worker exposure, vapor intrusion into buildings, and residential use of ground water from shallow wells for lawn and garden watering). The Human Health Risk Assessment Work Plan is in Volume 1B.

4. *Specify available resources and relevant deadlines for the study* - Solutia will provide the resources needed to meet the stated objectives. The project schedule is presented in Volume 1A, Section 16.0 of the SSP.

Step 2: Identify the decision - a statement of the decision that will use environmental data and the actions that could result from this decision.

1. *Identify the principal study decision* - What is the nature and extent of constituent migration in ground water at the site?

2. *Define alternative actions that could result from resolution of the principle study question* -

   a. Contaminant sources are characterized at the site, resulting in development of a site-specific risk assessment to develop remediation goals.

   b. Contaminant sources are not identified, resulting in no further action.

3. *Combine the principle study question and the alternative actions into a decision statement* -Determine the nature and extent of constituent migration in ground water at the site and develop a site-specific risk assessment to develop remediation goals.

4. *Organize multiple decisions* - Only one decision is being evaluated.

Step 3: Identify inputs to the decision - a list of environmental variables or characteristics that will be measured and other information needed to resolve the decision statement.

1. *Identify the information that will be required to resolve the decision statement* - To resolve the decision statement, the planning team needs to obtain measurements of contaminants, including VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofuran concentrations, presented in Table 1, at the site.

2. *Determine the sources for each item of the information identified* - The ground water will be tested using the methods listed in Table 2.

3. *Identify the information that is needed to establish the action level* - Based on the information generated through this study, the evaluation of potential human health risks, and consideration of preliminary remediation goals, a list of site-specific remedial action objectives for ground water will be developed that will be protective of human health and the environment. These objectives will specify the contaminant(s) and media of concern, the exposure route(s) and receptor(s), and an acceptable contaminant level or range of levels for each exposure route.

   Initially, preliminary remediation goals are developed based on readily available information, such as chemical-specific ARARs, or other reliable information. Preliminary remediation goals will be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected. Remediation goals will establish acceptable exposure levels that are protective of human health and the environment and will be developed by considering the following:

   - ARARs under federal environmental, state environmental, or facility siting laws, if available, and the following factors:

     - For systemic toxicants, acceptable exposure levels will represent concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effect

during a lifetime or part of a lifetime, incorporating an adequate margin of safety

- For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between $1x10^{-6}$ and 10^{-4} using information on the relationship between dose and response

- Factors related to technical limitations such as detection/ quantification limits for contaminants

- Factors related to uncertainty

- Other pertinent information.

- Maximum contaminant level goals (MCLGs), established under the Safe Drinking Water Act, that are set at levels above zero, will be attained by remedial actions for ground or surface waters that are current or potential sources of drinking water, where the MCLGs are relevant and appropriate under the circumstances of the release based on the National Contingency Plan (NCP) factors established in §300.400(g)(2). If an MCLG is determined not to be relevant and appropriate, the corresponding maximum contaminant level (MCL) will be attained where relevant and appropriate to the circumstances of the release.

- Where the MCLG for a contaminant has been set at a level of zero, the MCL promulgated for that contaminant under the Safe Drinking Water Act will be attained by remedial actions for ground or surface waters that are current or potential sources of drinking water, where the MCL is relevant and appropriate under the circumstances of the release based on the factors in §300.400(g)(2).

- Water quality criteria established under sections 303 or 304 of the Clean Water Act will be attained where relevant and appropriate under the circumstances of the release.

- An alternate concentration limit (ACL) may be established in accordance with CERCLA section 121(d)(2)(B)(ii).

4. *Confirm the appropriate measurement methods exist to provide the necessary data* - VOCs, SVOC, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofuran concentrations can be measured using the USEPA methods listed in Table 2. The laboratory

detection limits for the VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofurans are listed in Tables 5A through 5P.

Step 4: Define the boundaries of the study - a detailed description of the spatial and temporal boundaries of the problem, characteristics that define the population of interest, and any practical considerations of interest.

1. *Specify the characteristics that define the population of interest* - Ground water samples will be collected in the alluvial aquifer and bedrock at the fill areas, in the alluvial aquifer downgradient of the fill areas, and in shallow ground water and domestic wells adjacent to Dead Creek.

2. *Define the spatial boundary of the decision statement* -

   a. *Define the geographic area to which the decision statement applies* - Decisions will apply to the ground water containment plume in the alluvial aquifer and bedrock at the fill areas, the alluvial aquifer downgradient of the fill areas, and in the shallow ground water and domestic wells adjacent to Dead Creek.

   b. *When appropriate, divide the population into strata that have relatively homogenous characteristics* - Ground water samples are divided into the following categories: fill areas, alluvial aquifer, downgradient alluvial aquifer, bedrock, shallow residential area, and domestic wells.

3. *Define the temporal boundary of the decision statement* -

   a. *Determine the time frame to which the decision statement applies* - It will be assumed that the sampling data will represent current concentrations within the ground water.

   b. *Determine when to collect the data* - Ground water samples will be collected during one sampling round and analyzed for VOCs, SVOCs, metals, mercury, cyanide, PCBs, pesticides, herbicides, and dioxin constituents associated with the analytical methods listed in the FSP.

4. *Define the scale of decision making* - The scale of decision making will be from the extraction site for the one ground water sampling round.

5. *Identify practical constraints on data collection* - The most important practical constraint that could interfere with the study is interference in the ability to collect ground water samples in the field due to inclement weather and lack of access issues related to the private domestic wells.

Step 5: Develop a decision rule - to define the parameter of interest, specify the action level and integrate previous DQO outputs into a single statement that describes a logical basis for choosing among alternative actions

1. *Specify the statistical parameter that characterizes the population of interest* - The laboratory results from the one sampling event will characterize the population of interest. A statistical parameter is not being used because only one sampling event is scheduled; the small sample size would not result in meaningful sample statistics.

2. *Specify the action level for the study* - Preliminary remediation goals will be developed based on readily available information, such as chemical specific ARARs, or other reliable information. Preliminary remediation goals will be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected. Remediation goals will establish acceptable exposure levels that are protective of human health and the environment and will be developed as described above in part 3 of Step 3.

3. *Develop a decision rule* -

   a. If VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofuran concentrations exceed preliminary remediation goals, use site-specific risk assessment to develop remediation goals and complete the EE/CA and RI/FS reports.

   b. If VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofuran concentrations do not exceed preliminary remediation goals, no additional action is needed.

Step 6: Specify tolerable limits on decision errors - the decision maker's tolerable decision error rates based on a consideration of the consequences of making a decision error

1. *Determine the possible range of the parameter of interest* - The range of the expected constituents varies. The laboratory analysis will screen samples and adjust for the concentration ranges during the analysis process.

2. *Identify the decision errors and choose the null hypothesis*

   a. *Define both types of decision errors and establish the true state of nature for each decision error* - The planning team has determined that the two decision errors are (I) deciding that the nature and extent of ground water contamination is not already defined when it truly is; and (II) deciding that the nature and extent of ground water contamination is defined when it truly is not.

      - The true state of nature for the decision error (I) is that the nature and extent of ground water contamination is defined.

      - The true state of nature for the decision error (II) is that the nature and extent of ground water contamination is not defined.

   b. *Specify and evaluate the potential consequences of each decision error* - The consequences of deciding that the nature and extent of ground water contamination is not defined when it truly is will be that incorrect information is used in the risk assessment to develop remediation goals.

      The consequences of deciding that the nature and extent of ground water contamination is defined when it truly is not will be that migration of the ground water may pose a threat to off-site drinking water supplies.

   c. *Establish which decision error has more severe consequences of each decision error* - The planning team has concluded that the decision error (II) has more severe consequences near the action level because the risk of jeopardizing human health outweighs the consequences of having incorrect information for risk assessment and remediation goal development.

   d. *Define the null hypothesis (baseline condition) and the alternative hypothesis and assign the terms "false positive" and "false*

negative" to the appropriate decision error - The baseline condition or null hypothesis is "the nature and extent of ground water contamination is not defined."

The alternative hypothesis is "the nature and extent of ground water contamination is defined."

The false positive decision error occurs when the null hypothesis is rejected when it is true.

The false negative decision error occurs when the null hypothesis is not rejected when it is true.

3. *Specify the range of possible values of the parameters of interest where the consequences of decision errors are relatively minor (grey area)* - In this case, because the sample size is small, statistical methods cannot be used for data collection designs. Therefore, in order to avoid false negative decision errors, qualitative guidelines will be established.

4. *Assign probability values to points above and below the action level that reflect the tolerable probability for the occurrence of decision errors* - Not applicable to the data collection design.

Step 7: Optimize the plan

1. *Review the DQO outputs and existing environmental data* - In 1998, Ecology and Environment prepared a report (Sauget Area 1 Data Tables/Maps) for USEPA Region V that "summarized existing technical and PRP data for each subunit of the sites along with other information compiled during Ecology and Environment's file searches of various agencies and organizations." This report contains information obtained from work done by IEPA, E&E, Weston, G&M, and The Advent Group. Ground water constituent data is included in the January 19, 1999 AOC and summarized in section 1.1.7 of the FSP.

2. *Develop the general data collection design* - The data collection design will involve one ground water sampling round. QC samples will be collected as described on Table 3 of this QAPP. Following review of the results of the sampling round, a decision will be made to either reject the null hypothesis, or accept the null hypothesis.

Soil.

Step 1: State the problem - a description of the problem and specifications of available resources and relevant deadlines for the study.

1. *Identify the members of the planning team* - The members of the planning team will include the Solutia Remedial Project Manager, the ENSR Risk Assessor, the O'Brien & Gere Project Officer, the O'Brien & Gere Project Manager, the O'Brien & Gere Quality Assurance Officer, the O'Brien & Gere Field Leader, and the Savannah Laboratories Project Manager.

2. *Identify the primary decision maker* - There will be no primary decision maker; decisions will be made by consensus.

3. *Develop a concise description of the problem* - Dead Creek flooding events and/or wind-blown dust may have resulted in the distribution of constituents to soils on the properties adjacent to the creek. Therefore, soil samples will be collected in both undeveloped and developed areas that are susceptible to flooding and deposition of wind-blown dust. Specifically, floodplain soil sampling will be conducted in an area bounded by Queeny Road on the north, Falling Springs Road on the east, Illinois Route 157 on the south, and Illinois Route 3 (Mississippi Avenue) on the west. This is the area where water backs up at road crossings during heavy rains and where PCBs are known to occur in creek sediments. This area also includes most of the residential development in Sauget Area 1.

   Information from the soil sampling program will be used to evaluate the extent of migration due to overbank flooding and wind-blown dust deposition. In addition, surficial and subsurface soil information will be used in the human health risk assessment (construction/utility worker and residential exposure scenarios). The Human Health Risk Assessment Work Plan is in Volume 1B of the SSP.

4. *Specify available resources and relevant deadlines for the study* - Solutia will provide the resources needed to meet the stated objectives. The project schedule is presented in Volume 1A, Section 16.0 of the SSP.

Step 2: Identify the decision - a statement of the decision that will use environmental data and the actions that could result from this decision.

1. *Identify the principal study decision* - What is the nature and extent of constituent migration due to overbank flooding and wind-blown dust deposition at the site?

2. *Define alternative actions that could result from resolution of the principle study question* -

   a. Contaminant areas are characterized at the site, resulting in development of a site-specific risk assessment to develop remediation goals.

   b. Contaminant areas are not identified, resulting in no further action.

3. *Combine the principle study question and the alternative actions into a decision statement* - Determine the nature and extent of additional constituent migration to soil at the site and develop a site-specific risk assessment to develop remediation goals.

4. *Organize multiple decisions* - Only one decision is being evaluated.

Step 3: Identify inputs to the decision - a list of environmental variables or characteristics that will be measured and other information needed to resolve the decision statement.

1. *Identify the information that will be required to resolve the decision statement* - To resolve the decision statement, the planning team needs to obtain measurements of contaminants, including VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofuran concentrations, presented in Table 1, at the site.

2. *Determine the sources for each item of the information identified* - The soil will be tested using the methods listed in Table 2.

3. *Identify the information that is needed to establish the action level* - Surface soil samples will be collected, colocated with the fill area waste sample locations. These data will be used in the risk assessment. Floodplain soil samples will be collected every 200 ft on seven transects in undeveloped areas, a total of forty-five sampling stations. Based on these sampling results, twenty soil sampling stations will be located in developed areas. Three samples will be collected in developed areas adjacent to Transects 1, 2, 3, 4, 5, and 6, and two samples will be collected in developed areas adjacent to Transect 7, which is the transect at the downgradient limit of the residential area. Twenty developed area samples are considered an appropriate number for identification in the SSP until undeveloped area soil samples and Creek

Segment B, C, D, and E sediment samples are collected and analyzed. Then, this information on the extent and concentration of constituents in undeveloped area floodplain soils and creek sediments can be used to select developed area sampling locations. These data will also be used in the risk assessment. Background surface and subsurface soil samples will be collected at the locations of the background ground water wells and the data used in the risk assessment. COCs will be identified in the risk assessment and remedial goals will be developed for the COCs based on exposure pathways evaluated in the risk assessment.

4. *Confirm the appropriate measurement methods exist to provide the necessary data* - VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofuran concentrations can be measured using the USEPA methods listed in Table 2. The laboratory detection limits for the VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofurans are listed in Tables 5A through 5P.

Step 4: Define the boundaries of the study - a detailed description of the spatial and temporal boundaries of the problem, characteristics that define the population of interest, and any practical considerations of interest.

1. *Specify the characteristics that define the population of interest* - Surface soil samples will be collected, colocated with the fill area waste sampling locations. Surface and subsurface soil samples will be collected from undeveloped areas along seven transects as identified in the SSP in the residential/commercial/undeveloped area adjacent to Dead Creek. Based on the transect analytical results, surface and subsurface soil samples will be collected from three residences along each of Transects 1 through 6 and two residences along Transect 7. Background surface and subsurface soil samples will be collected at the locations of the background ground water wells.

2. *Define the spatial boundary of the decision statement* -

   a. *Define the geographic area to which the decision statement applies* - Decisions will apply to both undeveloped and developed areas adjacent to Dead Creek that are susceptible to flooding and

deposition of wind-blown dust. Specifically, in the area bounded by Queeny Road on the north, Falling Springs Road on the east, Illinois Route 157 on the south, and Illinois Route 3 (Mississippi Avenue) on the west.

b. *When appropriate, divide the population into strata that have relatively homogenous characteristics* - Soil samples are divided into the following categories: surface (0 to 0.5 ft below ground surface) and subsurface (0.5 to 6 ft below ground surface).

3. *Define the temporal boundary of the decision statement* -

   a. *Determine the time frame to which the decision statement applies* - It will be assumed that the sampling data will represent current concentrations within the soils.

   b. *Determine when to collect the data* - Soil samples will be collected during one sampling round and analyzed for VOCs, SVOCs, metals, mercury, cyanide, PCBs, pesticides, herbicides, and dioxin constituents associated with the analytical methods listed in the FSP. Based on the transect analytical results, surface and subsurface soil samples will be collected from three residences along each of Transects 1 through 6 and two residences along Transect 7.

4. *Define the scale of decision making* - The scale of decision making will be from the sampling site for the one soil sampling round.

5. *Identify practical constraints on data collection* - The most important practical constraint that could interfere with the study is interference in the ability to collect soil samples in the field due to inclement weather.

Step 5: Develop a decision rule - to define the parameter of interest, specify the action level and integrate previous DQO outputs into a single statement that describes a logical basis for choosing among alternative actions.

1. *Specify the statistical parameter that characterizes the population of interest* - The laboratory results from the one sampling event will characterize the population of interest. A statistical parameter is not being used because only one sampling event is scheduled; the small sample size would not result in meaningful sample statistics.

2. *Specify the action level for the study* - Preliminary remediation goals will be developed based on readily available information, such as chemical specific ARARs, or other reliable information. Preliminary

remediation goals will be modified, as necessary, as more information becomes available during the EE/CA process. Final remediation goals will be determined when the remedy is selected. Remediation goals will establish acceptable exposure levels that are protective of human health and the environment and will be developed as described in the Human Health Risk Assessment Work Plan in Volume 1B.

3. *Develop a decision rule* -

   a. If VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofuran concentrations exceed preliminary remediation goals, use site-specific risk assessment to develop remediation goals and complete the EE/CA and RI/FS reports.

   b. If VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, and dibenzofuran concentrations do not exceed preliminary remediation goals, no additional action is needed.

Step 6: Specify tolerable limits on decision errors - the decision maker's tolerable decision error rates based on a consideration of the consequences of making a decision error.

1. *Determine the possible range of the parameter of interest* - The range of the expected constituents varies. The laboratory analysis will screen samples and adjust for the concentration ranges during the analysis process.

2. *Identify the decision errors and choose the null hypothesis* -

   a. *Define both types of decision errors and establish the true state of nature for each decision error* - The planning team has determined that the two decision errors are (I) deciding that the nature and extent of soil contamination is not already defined when it truly is; and (II) deciding that the nature and extent of soil contamination is defined when it truly is not.

      - The true state of nature for the decision error (I) is that the nature and extent of soil contamination is defined.

- The true state of nature for the decision error (II) is that the nature and extent of soil contamination is not defined.

b. *Specify and evaluate the potential consequences of each decision error* - The consequences of deciding that the nature and extent of soil contamination is not defined when it truly is will be that incorrect information is used in the risk assessment to develop remediation goals.

   The consequences of deciding that the nature and extent of soil contamination is defined when it truly is not will be that the presence of constituents of concern in the soil may pose a threat to human health and/or off-site drinking water supplies.

c. *Establish which decision error has more severe consequences of each decision error* - The planning team has concluded that the decision error (II) has more severe consequences near the action level because the risk of jeopardizing human health outweighs the consequences of having incorrect information for risk assessment and remediation goal development.

d. *Define the null hypothesis (baseline condition) and the alternative hypothesis and assign the terms "false positive" and "false negative" to the appropriate decision error* - The baseline condition or null hypothesis is "the nature and extent of soil contamination is not defined."

   The alternative hypothesis is "the nature and extent of soil contamination is defined."

   The false positive decision error occurs when the null hypothesis is rejected when it is true.

   The false negative decision error occurs when the null hypothesis is not rejected when it is true.

3. *Specify the range of possible values of the parameters of interest where the consequences of decision errors are relatively minor (grey area)* - In this case, because the sample size is small, statistical methods cannot be used for data collection designs. Therefore, in order to avoid false negative decision errors, qualitative guidelines will be established.

4. *Assign probability values to points above and below the action level that reflect the tolerable probability for the occurrence of decision errors* - Not applicable to the data collection design.

Step 7: Optimize the plan

1. *Review the DQO outputs and existing environmental data* - In 1998, Ecology and Environment prepared a report (Sauget Area 1 Data Tables/Maps) for USEPA Region V that "summarized existing technical and PRP data for each subunit of the sites along with other information compiled during Ecology and Environment's file searches of various agencies and organizations." This report contains information obtained from work done by IEPA, E&E, Weston, G&M, and The Advent Group. Soil constituent data is included in the January 19, 1999 AOC and summarized in section 1.1.7 of the FSP.

2. *Develop the general data collection design* - The data collection design will involve one soil sampling round. QC samples will be collected as described on Table 3 of this QAPP. Following review of the results of the sampling round, a decision will be made to either reject the null hypothesis, or accept the null hypothesis.

Sediment.

Step 1: State the problem - a description of the problem and specifications of available resources and relevant deadlines for the study.

1. *Identify the members of the planning team* - The members of the planning team will include the Solutia Remedial Project Manager, the ENSR Risk Assessor, the O'Brien & Gere Project Officer, the O'Brien & Gere Project Manager, the O'Brien & Gere Quality Assurance Officer, the O'Brien & Gere Field Leader, and the Savannah Laboratories Project Manager.

2. *Identify the primary decision maker* - There will be no primary decision maker; decisions will be made by consensus.

3. *Develop a concise description of the problem* - Dead Creek stretches from the Alton & Southern Railroad at its northern end and flows south through Sauget and Cahokia for approximately 3.5 miles before emptying into the Old Prairie du Pont Creek, which flows approximately 2000 feet west into a branch of the Mississippi River known as the Cahokia Chute. For many years, Dead Creek has been a repository for local area wastes. On December 21, 1928, an easement

agreement between local property owners and representatives of local business, municipal, and property interests was executed to "improve the drainage in that District (Dead Creek) by improving Dead Creek so as to make it suitable for the disposal of wastewater, industrial waste, seepage and storm water." Thereafter, Dead Creek systematically received direct and indirect discharges from local businesses and from the Village for many years to come. For purposes of this study, Dead Creek has been divided into six segments, A-F. Fill area Site M is hydrologically connected to Dead Creek through an 8-ft opening at the southwest portion. On information and belief, wastes from Creek Segment CS-B have in the past and potentially continue to migrate into Site M via this connection.

Creek Segment CS-A is the northernmost segment of the creek. It is approximately 1800 feet long and 100 feet wide, running from the Alton & Southern Railroad to Queeny Avenue. This segment of the creek originally consisted of two holding ponds which were periodically dredged. For several years, CS-A and available downstream segments (*e.g.*, ones that were not blocked off) received direct wastewater discharges from industrial sources and served as a surcharge basin for the Village of Sauget (formerly the Village of Monsanto) municipal sewer collection system. When the system became backed up or overflowed, untreated wastes from industrial users of the sewer system were discharged directly into CS-A. On several occasions, CS-A was dredged and contaminated sediments were disposed of onto adjacent Site I. In 1968, the Queeny Avenue culvert, which allowed creek water to pass from CS-A to CS-B, was permanently blocked by the Village of Sauget.

Constituents in ground water may discharge to Dead Creek and subsequently be transported downstream to the lower reaches of Dead Creek and into Borrow Pit Lake. Fish in the Borrow Pit Lake may have accumulated constituents present in surface water and/or sediments. In addition, it is possible that Dead Creek flooding events may have resulted in the distribution of constituents to soils on the properties adjacent to the creek.

Vertically integrated sediment samples will be collected in Dead Creek to evaluate the extent of downstream migration of site-related constituents and to provide information for use in the human health risk assessment (recreational teenage and recreational fishing scenarios) and the ecological risk assessment (endpoint organism exposure to sediments). The Human Health Risk Assessment Work Plan is in Volume 1B of the SSP, and the Ecological Risk Assessment Work Plan is in Volume 1C. Given the 17,000-ft length of Dead Creek, sediment

sampling at 400-ft intervals will provide sufficient information to evaluate the extent of downstream migration of industry-specific constituents. As directed by USEPA Region V, sediment samples will be collected at 200-ft intervals in the undeveloped portions of Dead Creek (*i.e.*, Creek Segments B and F) and at 150-ft intervals in the developed portions of Dead Creek, specifically Creek Segments C, D, and E, to evaluate the extent of migration of industry-specific constituents. Industry-specific constituents include PCBs (discontinued chemical manufacturing operation), total petroleum hydrocarbons (TPH) (closed oil refinery), copper (active metal refining), and zinc (active metal refining). This information will also be used in the human health risk assessment.

Sediment samples will also be collected in Borrow Pit Lake to define downstream concentration distributions and gradients. In support of the Ecological Assessment Sampling Plan, sediment samples will be collected at the locations of ecological samples at sampling stations in Dead Creek and at Site M. The sediment samples collected for the Ecological Assessment will assist in the evaluation of the extent of downstream migration of target compound list/target analyte list (TCL/TAL) constituents. These broad-scan analyses are also intended to provide information for the ecological risk assessments. Samples will be collected from the biological active zone of the sediment. This zone is approximately within the top six inches of the sediment.

The extent of migration information collected as part of this task, coupled with sediment thickness measurements and channel cross-sectional area, will provide enough information to evaluate the volume of impacted sediments.

4. *Specify available resources and relevant deadlines for the study* - Solutia will provide the resources needed to meet the stated objectives. The project schedule is presented in Volume 1A, Section 16.0 of the SSP.

Step 2: Identify the decision - a statement of the decision that will use environmental data and the actions that could result from this decision.

1. *Identify the principal study decision* - What is the nature and extent of downstream migration of site-related constituents and what is the volume of impacted sediments at the site?

2. *Define alternative actions that could result from resolution of the principle study question* -

   a. Contaminant areas are characterized at the site, resulting in development of a site-specific risk assessment to develop remediation goals.

   b. Contaminant areas are not identified, resulting in no further action.

3. *Combine the principle study question and the alternative actions into a decision statement* - Determine the nature and extent of constituent migration to sediment and volume of impacted sediment at the site and develop a site-specific risk assessment to develop remediation goals.

4. *Organize multiple decisions* - Only one decision is being evaluated.

Step 3: Identify inputs to the decision - a list of environmental variables or characteristics that will be measured and other information needed to resolve the decision statement.

1. *Identify the information that will be required to resolve the decision statement* - To resolve the decision statement, the planning team needs to obtain measurements of contaminants, including VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, zinc, copper, dioxin, dibenzofuran, TPH, TOC, solids, hardness, pH, and grain size, presented in Table 1, at the site.

2. *Determine the sources for each item of the information identified* - The sediments will be tested using the methods listed in Table 2.

3. *Identify the information that is needed to establish the action level* - Vertically integrated sediment core samples will be collected at 200-ft intervals in Creek Segment B and Creek Segment F, at 150-ft intervals in Creek Segments C, D, and E to evaluate the extent of downstream migration of constituents related to specific industrial sources located at the upstream end of Dead Creek. Sampling at 200-ft intervals in the portion of Borrow Pit Lake north of the discharge of Dead Creek will be collected to define the distribution of industrial source-specific constituents resulting from the discharge of Dead Creek into Borrow Pit Lake.

Vertically integrated sediment core samples will be collected at 400-ft intervals from upstream end of Borrow Pit Lake in Creek Segment F down to the confluence of Dead Creek with the lake in order to evaluate the distribution of constituents related to specific industrial sources located at the upstream end of Dead Creek. Vertically integrated sediment core samples will be collected every 1000 ft in Dead Creek, from the upstream end of Creek Segment B to the downstream end of Creek Segment F at the Old Prairie du Pont Creek lift station, to evaluate the extent of downstream migration of TCL/TAL constituents. These broad-scan analyses are also intended to provide information for the human health risk assessment.

Two sediment core samples will be collected in Borrow Pit Lake in Creek Segment F upstream of the discharge of Dead Creek to assess the effect of backwater conditions and/or the contributions of other sources. One sample will be collected upstream, and one sample will be collected downstream of the confluence of Dead Creek and Old Prairie du Pont Creek to evaluate the impact of the Dead Creek discharge on sediment quality in Old Prairie du Pont Creek.

In support of the Ecological Assessment Sampling Plan, sediment samples will be collected at the number of sampling stations indicated at each of the creek segments (A-F) and at Site M. Each sediment sampling station will coincide with the location where Menzie-Cura will be collecting ecological samples for evaluation and will be collected during the ecological sample collection activities.

The sediment samples collected for the Ecological Assessment will assist in the evaluation of the extent of downstream migration of TCL/TAL constituents. These broad-scan analyses are also intended to provide information for the ecological risk assessments. Samples will be collected from the biological active zone of the sediment. This zone is approximately within the top six inches of the sediment.

COCs will be identified in the risk assessment and remedial goals will be developed for the COCs based on exposure pathways evaluated in the risk assessment.

4. *Confirm the appropriate measurement methods exist to provide the necessary data* - VOCs, SVOCs, pesticides, PCBs, herbicides, metals,

mercury, cyanide, zinc, copper, dioxin, dibenzofuran, TPH, TOC, solids, hardness, pH, and grain size can be measured using the USEPA methods listed in Table 2. The laboratory detection limits for the analyses are listed in Tables 5A through 5P.

Step 4: Define the boundaries of the study - a detailed description of the spatial and temporal boundaries of the problem, characteristics that define the population of interest, and any practical considerations of interest.

1. *Specify the characteristics that define the population of interest* - Sediment samples will be collected at the locations and intervals identified in the SSP along Dead Creek Segments CS-A through CS-F, and in Borrow Pit Lake.

2. *Define the spatial boundary of the decision statement* -

   a. *Define the geographic area to which the decision statement applies* - Decisions will apply to both undeveloped and developed areas along Dead Creek, and in Borrow Pit Lake.

b. *When appropriate divide the population into strata that have relatively homogenous characteristics* - Sediment samples are divided into the following categories: undeveloped area, developed area, Borrow Pit Lake, Dead Creek, and ecological as described in Sections 5.20.1 to 5.20.5 in the FSP.

3. *Define the temporal boundary of the decision statement* -

   a. *Determine the time frame to which the decision statement applies* - It will be assumed that the sampling data will represent current concentrations within the sediments.

   b. *Determine when to collect the data* - Sediment samples will be collected during one sampling round and analyzed for VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, zinc, copper, dioxin, dibenzofuran, TPH, TOC, solids, hardness, pH, and grain size constituents associated with the analytical methods listed in the FSP.

4. *Define the scale of decision making* - The scale of decision making will be from the sampling site for the one sediment sampling round.

5. *Identify practical constraints on data collection* - The most important practical constraint that could interfere with the study is interference in

the ability to collect sediment samples in the field due to inclement weather.

Step 5: Develop a decision rule - to define the parameter of interest, specify the action level, and integrate previous DQO outputs into a single statement that describes a logical basis for choosing among alternative actions.

1. *Specify the statistical parameter that characterizes the population of interest* - The laboratory results from the one sampling event will characterize the population of interest. A statistical parameter is not being used because only one sampling event is scheduled; the small sample size would not result in meaningful sample statistics.

2. *Specify the action level for the study* - Preliminary remediation goals will be developed based on readily available information, such as chemical- specific ARARs, or other reliable information. Preliminary remediation goals will be modified, as necessary, as more information becomes available during the EE/CA process. Final remediation goals will be determined when the remedy is selected. Remediation goals will establish acceptable exposure levels that are protective of human health and the environment and will be developed as described in the Human Health Risk Assessment Work Plan in Volume 1B.

3. *Develop a decision rule* -

   a. If VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, zinc, copper, dioxin, dibenzofuran, TPH, TOC, solids, hardness, pH, and grain size measurements exceed preliminary remediation goals, use site-specific risk assessment to develop remediation goals and complete the EE/CA and RI/FS reports.

   b. If VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, zinc, copper, dioxin, dibenzofuran, TPH, TOC, solids, hardness, pH, and grain size measurements do not exceed preliminary remediation goals , no additional action is needed.

Step 6: Specify tolerable limits on decision errors - the decision maker's tolerable decision error rates based on a consideration of the consequences of making a decision error.

1. *Determine the possible range of the parameter of interest* - The range of the expected constituents varies. The laboratory analysis will screen samples and adjust for the concentration ranges during the analysis process.

2. *Identify the decision errors and choose the null hypothesis* -

   a. *Define both types of decision errors and establish the true state of nature for each decision error* - The planning team has determined that the two decision errors are (I) deciding that the nature and extent of sediment contamination is not already defined when it truly is; and (II) deciding that the nature and extent of sediment contamination is defined when it truly is not.

      - The true state of nature for the decision error (I) is that the nature and extent of sediment contamination is defined.

      - The true state of nature for the decision error (II) is that the nature and extent of sediment contamination is not defined.

   b. *Specify and evaluate the potential consequences of each decision error* - The consequences of deciding that the nature and extent of sediment contamination is not defined when it truly is will be that incorrect information is used in the risk assessment to develop remediation goals.

      The consequences of deciding that the nature and extent of sediment contamination is defined when it truly is not will be that the presence of constituents of concern in the sediments may pose a threat to human health and/or off-site drinking water supplies.

   c. *Establish which decision error has more severe consequences of each decision error* - The planning team has concluded that the decision error (II) has more severe consequences near the action level because the risk of jeopardizing human health outweighs the consequences of having incorrect information for risk assessment and remediation goal development.

   d. *Define the null hypothesis (baseline condition) and the alternative hypothesis and assign the terms "false positive" and "false negative" to the appropriate decision error* - The baseline condition or null hypothesis is "the nature and extent of sediment contamination is not defined."

The alternative hypothesis is "the nature and extent of sediment contamination is defined."

The false positive decision error occurs when the null hypothesis is rejected when it is true.

The false negative decision error occurs when the null hypothesis is not rejected when it is true.

3. *Specify the range of possible values of the parameters of interest where the consequences of decision errors are relatively minor (grey area)* - In this case, because the sample size is small, statistical methods cannot be used for data collection designs. Therefore, in order to avoid false negative decision errors, qualitative guidelines will be established.

4. *Assign probability values to points above and below the action level that reflect the tolerable probability for the occurrence of decision errors* - Not applicable to the data collection design.

Step 7: Optimize the plan

1. *Review the DQO outputs and existing environmental data* - In 1998, Ecology and Environment prepared a report (Sauget Area 1 Data Tables/Maps) for USEPA Region V that "summarized existing technical and PRP data for each subunit of the sites along with other information compiled during Ecology and Environment's file searches of various agencies and organizations." This report contains information obtained from work done by IEPA, E&E, Weston, G&M, and The Advent Group. Sediment constituent data is included in the January 19, 1999 AOC and summarized in section 1.1.8 of the FSP.

2. *Develop the general data collection design* - The data collection design will involve one sediment sampling round. QC samples will be collected as described on Table 3 of this QAPP. Following review of the results of the sampling round, a decision will be made to either reject the null hypothesis, or accept the null hypothesis.

Surface water.

Step 1: State the problem- a description of the problem and specifications of available resources and relevant deadlines for the study.

1. *Identify the members of the planning team* - The members of the planning team will include the Solutia Remedial Project Manager, the ENSR Risk Assessor, the O'Brien & Gere Project Officer, the O'Brien & Gere Project Manager, the O'Brien & Gere Quality Assurance Officer, the O'Brien & Gere Field Leader, and the Savannah Laboratories Project Manager.

2. *Identify the primary decision maker* - There will be no primary decision maker; decisions will be made by consensus.

3. *Develop a concise description of the problem* - Dead Creek stretches from the Alton & Southern Railroad at its northern end and flows south through Sauget and Cahokia for approximately 3.5 miles before emptying into the Old Prairie du Pont Creek, which flows approximately 2000 feet west into a branch of the Mississippi River known as the Cahokia Chute. For many years, Dead Creek has been a repository for local area wastes. On December 21, 1928, an easement agreement between local property owners and representatives of local business, municipal and property interests was executed to "improve the drainage in that District (Dead Creek) by improving Dead Creek so as to make it suitable for the disposal of wastewater, industrial waste, seepage and storm water." Thereafter, Dead Creek systematically received direct and indirect discharges from local businesses and from the Village for many years to come. For purposes of this study, Dead Creek has been divided into six segments, A-F. Fill area Site M is hydrologically connected to Dead Creek through an 8-ft opening at the southwest portion. On information and belief, wastes from Creek Segment CS-B have in the past and potentially continue to migrate into Site M via this connection.

Creek Segment CS-A is the northernmost segment of the creek. It is approximately 1800 feet long and 100 feet wide, running from the Alton & Southern Railroad to Queeny Avenue. This segment of the creek originally consisted of two holding ponds which were periodically dredged. For several years, CS-A and available downstream segments (*e.g.*, ones that were not blocked off) received direct wastewater discharges from industrial sources and served as a surcharge basin for the Village of Sauget (formerly the Village of Monsanto) municipal sewer collection system. When the system became backed up or overflowed, untreated wastes from industrial users of the sewer system were discharged directly into CS-A. On several occasions, CS-A was dredged and contaminated sediments were disposed of onto adjacent Site I. In 1968, the Queeny Avenue culvert, which

allowed creek water to pass from CS-A to CS-B, was permanently blocked by the Village of Sauget.

Constituents in ground water may discharge to Dead Creek and subsequently be transported downstream to the lower reaches of Dead Creek and into Borrow Pit Lake. Fish in the Borrow Pit Lake may have accumulated constituents present in surface water and/or sediments. In addition, it is possible that Dead Creek flooding events may have resulted in the distribution of constituents to soils on the properties adjacent to the creek.

Surface water samples will be collected to evaluate the extent of downstream migration of site-related constituents and to provide information for use in the human health risk assessment (trespasser and recreational fishing scenarios) and the ecological risk assessment (endpoint organism exposure to surface water). The Human Health Risk Assessment Work Plan is in Volume 1B of the SSP and the Ecological Risk Assessment Work Plan is in Volume 1B.

Surface water samples will be collected every 1000 ft in Dead Creek, from the upstream end of Segment B to the downstream end of Segment F at the Old Prairie du Pont Creek lift station, to evaluate the extent of downstream migration of site-related constituents.

Two surface water samples will be collected in Borrow Pit Lake in Creek Segment F upstream of the discharge of Dead Creek to assess the effect of backwater conditions and/or the contributions of other sources. One sample will be collected upstream and one sample will be collected downstream of the confluence of Dead Creek and Old Prairie du Pont Creek to evaluate the impact of the Dead Creek discharge on surface water quality in Old Prairie du Pont Creek.

4. *Specify available resources and relevant deadlines for the study* - Solutia will provide the resources needed to meet the stated objectives. The project schedule is presented in Volume 1A, Section 16.0 of the SSP.

Step 2: Identify the decision - a statement of the decision that will use environmental data and the actions that could result from this decision.

1. *Identify the principal study decision* - What is the nature and extent of downstream migration of site-related constituents in surface water at the site?

2. *Define alternative actions that could result from resolution of the principle study question* -

   a. Contaminant areas are characterized at the site, resulting in development of a site-specific risk assessment to develop remediation goals.

   b. Contaminant areas are not identified, resulting in no further action.

3. *Combine the principle study question and the alternative actions into a decision statement* - Determine the nature and extent of constituent migration to surface water at the site and develop a site-specific risk assessment to develop remediation goals.

4. *Organize multiple decisions* - Only one decision is being evaluated.

Step 3: Identify inputs to the decision - a list of environmental variables or characteristics that will be measured and other information needed to resolve the decision statement.

1. *Identify the information that will be required to resolve the decision statement* - To resolve the decision statement, the planning team needs to obtain measurements of contaminants, including VOCs, SVOCs, metals, mercury, cyanide, fluoride, total phosphorus, orthophosphate, pesticides, PCBs, herbicides, dioxin, dibenzofuran, TSS, TDS, solids, hardness, and pH, presented in Table 1, at the site.

2. *Determine the sources for each item of the information identified* - The sediments will be tested using the methods listed in Table 2.

3. *Identify the information that is needed to establish the action level* - Surface water samples will be collected every 1000 ft in Dead Creek, from the upstream end of Segment B to the downstream end of Segment F at the Old Prairie du Pont Creek lift station, to evaluate the extent of downstream migration of site-related constituents.

   Two surface water samples will be collected in Borrow Pit Lake in Creek Segment F upstream of the discharge of Dead Creek to assess the effect of backwater conditions and/or the contributions of other sources. One sample will be collected upstream and one sample will be collected downstream of the confluence of Dead Creek and Old Prairie du Pont

Creek to evaluate the impact of the Dead Creek discharge on surface water quality in Old Prairie du Pont Creek.

COCs will be identified in the risk assessment and remedial goals will be developed for the COCs based on exposure pathways evaluated in the risk assessment.

4. *Confirm the appropriate measurement methods exist to provide the necessary data* - VOCs, SVOCs, metals, mercury, cyanide, fluoride, total phosphorus, orthophosphate, pesticides, PCBs, herbicides, dioxin, dibenzofuran, TSS, TDS, solids, hardness, and pH can be measured using the USEPA methods listed in Table 2. The laboratory detection limits for the analyses are listed in Tables 5A through 5P.

Step 4: Define the boundaries of the study - a detailed description of the spatial and temporal boundaries of the problem, characteristics that define the population of interest, and any practical considerations of interest.

1. *Specify the characteristics that define the population of interest* - Surface water samples will be collected at the locations and intervals identified in the SSP along Dead Creek Segments CS-A through CS-F, in Borrow Pit Lake, and upstream in Old Prairie du Pont Creek.

2. *Define the spatial boundary of the decision statement* -

    a. *Define the geographic area to which the decision statement applies* - Decisions will apply to areas along Dead Creek, in Borrow Pit Lake, and in Old Prairie du Pont Creek.

    b. *When appropriate divide the population into strata that have relatively homogenous characteristics* - Surface water samples are divided into the following categories: Dead Creek Segments CS-A through CS-F, Borrow Pit Lake, and Old Prairie du Pont Creek as described in Section 5.21.1 in the FSP.

3. *Define the temporal boundary of the decision statement* -

    a. *Determine the time frame to which the decision statement applies* - It will be assumed that the sampling data will represent current concentrations within the surface waters.

b. *Determine when to collect the data* - Surface water samples will be collected during one sampling round and analyzed for VOCs, SVOCs, metals, mercury, cyanide, fluoride, total phosphorus, orthophosphate, pesticides, PCBs, herbicides, dioxin, dibenzofuran, TSS, TDS, solids, hardness, and pH constituents associated with the analytical methods listed in the FSP.

4. *Define the scale of decision making* - The scale of decision making will be from the sampling site for the one surface water sampling round.

5. *Identify practical constraints on data collection* - The most important practical constraint that could interfere with the study is interference in the ability to collect surface water samples in the field due to inclement weather.

Step 5: Develop a decision rule - to define the parameter of interest, specify the action level and integrate previous DQO outputs into a single statement that describes a logical basis for choosing among alternative actions.

1. *Specify the statistical parameter that characterizes the population of interest* - The laboratory results from the one sampling event will characterize the population of interest. A statistical parameter is not being used because only one sampling event is scheduled; the small sample size would not result in meaningful sample statistics.

2. *Specify the action level for the study* - Preliminary remediation goals will be developed based on readily available information, such as chemical specific ARARs, or other reliable information. Preliminary remediation goals will be modified, as necessary, as more information becomes available during the EE/CA process. Final remediation goals will be determined when the remedy is selected. Remediation goals will establish acceptable exposure levels that are protective of human health and the environment and will be developed as described in the Human Health Risk Assessment Work Plan in Volume 1B.

3. *Develop a decision rule* -

   a. If VOCs, SVOCs, metals, mercury, cyanide, fluoride, total phosphorus, orthophosphate, pesticides, PCBs, herbicides, dioxin, dibenzofuran, TSS, TDS, solids, hardness, and pH measurements exceed preliminary remediation goals, use site-specific risk assessment to develop remediation goals and complete the EE/CA and RI/FS reports.

b. If VOCs, SVOCs, metals, mercury, cyanide, fluoride, total phosphorus, orthophosphate, pesticides, PCBs, herbicides, dioxin, dibenzofuran, TSS, TDS, solids, hardness, and pH measurements do not exceed preliminary remediation goals, no additional action is needed.

Step 6: Specify tolerable limits on decision errors - the decision maker's tolerable decision error rates based on a consideration of the consequences of making a decision error.

1. *Determine the possible range of the parameter of interest* - The range of the expected constituents varies. The laboratory analysis will screen samples and adjust for the concentration ranges during the analysis process.

2. *Identify the decision errors and choose the null hypothesis* -

   a. *Define both types of decision errors and establish the true state of nature for each decision error* - The planning team has determined that the two decision errors are (I) deciding that the nature and extent of surface water contamination is not already defined when it truly is; and (II) deciding that the nature and extent of surface water contamination is defined when it truly is not.

      - The true state of nature for the decision error (I) is that the nature and extent of surface water contamination is defined.

      - The true state of nature for the decision error (II) is that the nature and extent of surface water contamination is not defined.

   b. *Specify and evaluate the potential consequences of each decision error* - The consequences of deciding that the nature and extent of surface water contamination is not defined when it truly is will be that incorrect information is used in the risk assessment to develop remediation goals.

      The consequences of deciding that the nature and extent of surface water contamination is defined when it truly is not will be that the presence of constituents of concern in the surface waters may pose a threat to human health and/or off-site drinking water supplies.

c. *Establish which decision error has more severe consequences of each decision error* - The planning team has concluded that the decision error (II) has more severe consequences near the action level because the risk of jeopardizing human health outweighs the consequences of having incorrect information for risk assessment and remediation goal development.

d. *Define the null hypothesis (baseline condition) and the alternative hypothesis and assign the terms "false positive" and "false negative" to the appropriate decision error* - The baseline condition or null hypothesis is "the nature and extent of surface water contamination is not defined."

The alternative hypothesis is "the nature and extent of surface water contamination is defined."

The false positive decision error occurs when the null hypothesis is rejected when it is true.

The false negative decision error occurs when the null hypothesis is not rejected when it is true.

3. *Specify the range of possible values of the parameters of interest where the consequences of decision errors are relatively minor (grey area)* - In this case, because the sample size is small, statistical methods cannot be used for data collection designs. Therefore, in order to avoid false negative decision errors, qualitative guidelines will be established.

4. *Assign probability values to points above and below the action level that reflect the tolerable probability for the occurrence of decision errors* - Not applicable to the data collection design.

Step 7: Optimize the plan

1. *Review the DQO outputs and existing environmental data* - In 1998, Ecology and Environment prepared a report (Sauget Area 1 Data Tables/Maps) for USEPA Region V that "summarized existing technical and PRP data for each subunit of the sites along with other information compiled during Ecology and Environment's file searches of various agencies and organizations." This report contains information obtained from work done by IEPA, E&E, Weston, G&M, and The Advent Group. Surface water constituent data is included in the January 19, 1999 AOC and summarized in section 1.1.8 of the FSP.

2. *Develop the general data collection design* - The data collection design will involve one surface water sampling round. QC samples will be collected as described on Table 3 of this QAPP. Following review of the results of the sampling round, a decision will be made to either reject the null hypothesis, or accept the null hypothesis.

Air.

Step 1: State the problem - a description of the problem and specifications of available resources and relevant deadlines for the study.

1. *Identify the members of the planning team* - The members of the planning team will include the Solutia Remedial Project Manager, the ENSR Risk Assessor, the O'Brien & Gere Project Officer, the O'Brien & Gere Project Manager, the O'Brien & Gere Quality Assurance Officer, the O'Brien & Gere Field Leader, and the Savannah Laboratories Project Manager.

2. *Identify the primary decision maker* - There will be no primary decision maker; decisions will be made by consensus.

3. *Develop a concise description of the problem* - At Sauget Area 1, the fill areas are identified as Sites G, H, I, L, M, and N. Volatile organic compounds (VOCs) in ground water may volatilize into outdoor air and may infiltrate into air in overlying buildings. Windblown dust may have resulted in the distribution of constituents to soils on the properties adjacent to Dead Creek. Ambient air sampling will be conducted to determine the tendency of site constituents to enter the atmosphere and local wind patterns. Air samples will be collected in the vicinity of Sites G, H, I, and L and analyzed for VOCs, SVOCs, PCBs, dioxin, dibenzofuran, and metals. Because these are 24-hour air samples collected at a single time point, they will not be used in the calculation of risks in the Human Health Risk Assessment. The Human Health Risk Assessment Work Plan is in Volume 1B. However, the data will be compared to chronic and, if appropriate, to subchronic or acute criteria. Initial comparison will be made to USEPA Region 9 Preliminary Remediation Goals for Air.

4. *Specify available resources and relevant deadlines for the study* - Solutia will provide the resources needed to meet the stated objectives.

The project schedule is presented in Volume 1A, Section 16.0 of the SSP.

Step 2: Identify the decision - a statement of the decision that will use environmental data and the actions that could result from this decision.

1. *Identify the principal study decision* - What is the tendency of site constituents to enter the atmosphere and what are the local wind patterns at the site?

2. *Define alternative actions that could result from resolution of the principle study question* -

   a. Contaminant areas are characterized at the site, resulting in development of a site-specific risk assessment to develop remediation goals.

b. Contaminant areas are not identified, resulting in no further action.

3. *Combine the principle study question and the alternative actions into a decision statement* - Determine the tendency of site constituents to enter the atmosphere and the local wind patterns at the site and develop a site-specific risk assessment to develop remediation goals.

4. *Organize multiple decisions* - Only one decision is being evaluated.

Step 3: Identify inputs to the decision - a list of environmental variables or characteristics that will be measured and other information needed to resolve the decision statement.

1. *Identify the information that will be required to resolve the decision statement* - To resolve the decision statement, the planning team needs to obtain measurements of contaminants, including VOCs, SVOCs, metals, PCBs, dioxin, and dibenzofuran presented in Table 1, at the site.

2. *Determine the sources for each item of the information identified* - The air samples will be tested using the methods listed in Table 2.

3. *Identify the information that is needed to establish the action level* - Ambient air sampling will be conducted to determine the tendency of site constituents to enter the atmosphere and local wind patterns. Air samples will be collected in the vicinity of Sites G, H, I, and L and analyzed for VOCs, SVOCs, PCBs, dioxin, dibenzofuran, and metals. Because these are 24-hour air samples collected at a single time point, they will not be used in the calculation of risks in the Human Health

Risk Assessment. The Human Health Risk Assessment Work Plan is in Volume 1B. However, the data will be compared to chronic and, if appropriate, to subchronic or acute criteria. Initial comparison will be made to USEPA Region 9 Preliminary Remediation Goals for Air .

COCs will be identified in the risk assessment and remedial goals will be developed for the COCs based on exposure pathways evaluated in the risk assessment.

4. *Confirm the appropriate measurement methods exist to provide the necessary data* - VOCs, SVOCs, PCBs, dioxin, dibenzofuran, and metals can be measured using the USEPA methods listed in Table 2. The laboratory detection limits for the analyses are listed in Tables 5A through 5P.

Step 4: Define the boundaries of the study - a detailed description of the spatial and temporal boundaries of the problem, characteristics that define the population of interest, and any practical considerations of interest.

1. *Specify the characteristics that define the population of interest* - Air samples will be collected in the vicinity of Sites G, H, I, and L .

2. *Define the spatial boundary of the decision statement* -

   a. *Define the geographic area to which the decision statement applies* - Decisions will apply to areas in the vicinity of Sites G, H, I, and L.

   b. *When appropriate divide the population into strata that have relatively homogenous characteristics* - Air samples are divided into the following categories: Sites G, H, I, and L as described in Section 5.22.1 in the FSP.

3. *Define the temporal boundary of the decision statement* -

   a. *Determine the time frame to which the decision statement applies* - It will be assumed that the sampling data will represent current concentrations in the ambient air.

   b. *Determine when to collect the data* - Ambient air samples will be collected during one sampling round and analyzed for VOCs,

SVOCs, PCBs, dioxin, dibenzofuran, and metals constituents associated with the analytical methods listed in the FSP.

4. *Define the scale of decision making*- The scale of decision making will be from the sampling site for the one ambient air sampling round.

5. *Identify practical constraints on data collection* - The most important practical constraint that could interfere with the study is interference in the ability to collect ambient air samples in the field due to inclement weather.

Step 5: Develop a decision rule - to define the parameter of interest, specify the action level and integrate previous DQO outputs into a single statement that describes a logical basis for choosing among alternative actions.

1. *Specify the statistical parameter that characterizes the population of interest* - The laboratory results from the one sampling event will characterize the population of interest. A statistical parameter is not being used because only one sampling event is scheduled; the small sample size would not result in meaningful sample statistics.

2. *Specify the action level for the study* - Because these are 24-hour air samples collected at a single time point, they will not be used in the calculation of risks in the Human Health Risk Assessment. However, the data will be compared to chronic and, if appropriate, to subchronic or acute criteria. Initial comparison will be made to USEPA Region 9 Preliminary Remediation Goals for Air (USEPA, 1986c). Remediation goals will establish acceptable exposure levels that are protective of human health and the environment and will be developed as described in the Human Health Risk Assessment Work Plan in Volume 1B.

3. *Develop a decision rule* -

   a. If VOCs, SVOCs, PCBs, dioxin, dibenzofuran, and metals measurements exceed preliminary remediation goals, use site-specific risk assessment to develop remediation goals and complete the EE/CA and RI/FS reports.

   b. If VOCs, SVOCs, PCBs, dioxin, dibenzofuran, and metals measurements do not exceed preliminary remediation goals, no additional action is needed.

Step 6: Specify tolerable limits on decision errors - the decision maker's tolerable decision error rates based on a consideration of the consequences of making a decision error.

1. *Determine the possible range of the parameter of interest* - The range of the expected constituents varies. The laboratory analysis will screen samples and adjust for the concentration ranges during the analysis process.

2. *Identify the decision errors and choose the null hypothesis* -

   a. *Define both types of decision errors and establish the true state of nature for each decision error* - The planning team has determined that the two decision errors are (I) deciding that the nature and extent of ambient air contamination is not already defined when it truly is; and (II) deciding that the nature and extent of ambient air contamination is defined when it truly is not.

      - The true state of nature for the decision error (I) is that the nature and extent of ambient air contamination is defined.

      - The true state of nature for the decision error (II) is that the nature and extent of ambient air contamination is not defined.

   b. *Specify and evaluate the potential consequences of each decision error* - The consequences of deciding that the extent of ambient air contamination is not defined when it truly is will be that incorrect information is used in the risk assessment to develop remediation goals.

      The consequences of deciding that the extent of ambient air contamination is defined when it truly is not will be that the presence of constituents of concern in ambient air may pose a threat to human health.

   c. *Establish which decision error has more severe consequences of each decision error* - The planning team has concluded that the decision error (II) has more severe consequences near the action level because the risk of jeopardizing human health outweighs the

consequences of having incorrect information for risk assessment and remediation goal development.

d. *Define the null hypothesis (baseline condition) and the alternative hypothesis and assign the terms "false positive" and "false negative" to the appropriate decision error* - The baseline condition or null hypothesis is "the nature and extent of ambient air contamination is not defined."

The alternative hypothesis is "the nature and extent of ambient air contamination is defined."

The false positive decision error occurs when the null hypothesis is rejected when it is true.

The false negative decision error occurs when the null hypothesis is not rejected when it is true.

3. *Specify the range of possible values of the parameters of interest where the consequences of decision errors are relatively minor (grey area)* - In this case, because the sample size is small, statistical methods cannot be used for data collection designs. Therefore, in order to avoid false negative decision errors, qualitative guidelines will be established.

4. *Assign probability values to points above and below the action level that reflect the tolerable probability for the occurrence of decision errors* - Not applicable to the data collection design.

Step 7: Optimize the plan

1. *Review the DQO outputs and existing environmental data* - Ambient air data is not available from previous sampling events described in the AOC.

2. *Develop the general data collection design* - The data collection design will involve one ambient air sampling round. QC samples will be collected as described on Table 3 of this QAPP. Following review of the results of the sampling round, a decision will be made to either reject the null hypothesis, or accept the null hypothesis.

Specific data quality requirements, such as criteria for precision, accuracy, representativeness, completeness, comparability, and sensitivity, are specified in Chapter 3 of this QAPP.

Laboratory analyses and analytical levels will adhere to the guidelines described in USEPA's *Data Quality Objectives Process For Superfund, Interim Final Guidance* (USEPA, 1993c). Analytical levels are defined in the guidance document as follows:

- Screening data are defined as data generated by rapid, less precise methods of analysis with less rigorous sample preparation. For this project, screening data will be generated for pH, turbidity, temperature, and conductivity through field measurements. The level of QC that will be performed for the field measurements includes the QC efforts for pH, field conductivity, turbidity, and temperature measurements described in section 3.7, the field instrument calibration procedures described in section 6.1, and the quality objectives for precision and accuracy listed in Tables 6A through 6N of this QAPP.

- Definitive data are data generated using rigorous analytical methods, such as USEPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. For this project, definitive data will be generated by the analysis of soil, ground water, surface water, sediments, and air for organics and inorganics by USEPA methods. The level of QC that will be performed for the definitive data includes the QC efforts described in section 3.7, the calibration procedures described in section 6.2, the laboratory quality control checks described in section 8.2, the QC requirements listed in Tables 7A through 7I, and the control limits listed in Tables 6A through 6N of this QAPP.

1.6. Sample design and rationale

The sample network design is described in the FSP.

1.6.1. Sample network by task and matrix

The field sampling summary information, including the parameters, matrices, number of environmental samples, and the frequency of

associated QC samples, is presented in Table 3. Each sample collection activity is described in the FSP.

1.6.2. Site maps of sampling locations

Site plans showing sampling locations are located in Figures 1 through 10 of the SSP.

1.6.3. Rationale of selected sampling locations

The sample network design is described in the SSP and the FSP.

1.7. Project schedule

The estimated project schedule is presented in the Volume 1A, section 16.0 of the SSP.

2. Project organization and responsibility

O'Brien & Gere will perform the field activities, prepare the report, and provide project management for support sampling activities. Analytical services for this SSP will be provided by Savannah Labs & Environmental Services, Inc. (Savannah Labs) in Savannah, Georgia. Analytical services for dioxin and dibenzofuran for this SSP will be provided by Triangle Laboratories, Inc. (Triangle Labs) in Durham, North Carolina. The various quality assurance and management responsibilities of key project personnel are defined below.

2.1. Project organization

Sections 2.2 through 2.5 of this QAPP present the responsibilities of the key project personnel and the lines of authority for the project personnel are described in each section. Figure 1 is a project organization chart for the project.

2.2. Management responsibilities

2.2.1. USEPA Region V remedial project manager

Michael McAteer will serve as the USEPA Region V Remedial Project Manager (USEPA RPM). As such, he will have overall responsibility for all phases of the SSP.

2.2.2. Illinois Environmental Protection Agency (IEPA) remedial project manager

Candy Morin will serve as the IEPA Remedial Project Manager.

2.2.3. Solutia Inc. remedial project manager

Bruce S. Yare of Solutia will serve as the Solutia RPM. As such, he will have the overall responsibility for all phases of the SSP. He will be responsible for implementing the project, and will have the authority to commit the resources necessary to meet project objectives and requirements. The Solutia RPM's primary function is to verify that technical, financial, and scheduling objectives are achieved successfully. The Solutia RPM will report directly to USEPA Region V and will provide the major point of contact and control for matters concerning the project. The Solutia RPM will:

- Define project objectives and develop a sampling plan schedule
- Establish project policy and procedures to address the specific needs of the project as a whole, as well as the objectives of each task
- Acquire and apply technical and corporate resources as needed to verify performance within budget and schedule constraints
- Monitor and direct the field leaders
- Develop and meet ongoing project staffing requirements
- Review the work performed on each task to verify its quality, responsiveness, and timeliness
- Review and analyze overall task performance with respect to planned requirements and authorizations
- Approve reports before their submission to USEPA Region V
- Ultimately be responsible for the preparation and quality of reports
- Represent the project team at meetings.

2.2.4. O'Brien & Gere project officer

Dean L. Palmer, PE, will serve as the O'Brien & Gere Project Officer. As such, he is responsible for the overall administration and technical execution of the project. He will report directly to the Solutia RPM.

2.2.5. O'Brien & Gere project manager

Alan J. Cork, PE, will serve as the O'Brien & Gere Project Manager (PM). As such, he will have overall responsibility for verifying that the project

meets USEPA's objectives and O'Brien & Gere's quality standards. He will provide assistance to the Solutia RPM in terms of writing and distributing the QAPP to those parties connected with the project (including the laboratory). He will report directly to the O'Brien & Gere Project Officer and is responsible for technical quality control and project oversight.

2.3. Quality assurance (QA) responsibilities

2.3.1. Environmental Standards data validator

Kathy Blaine of Environmental Standards in Belleville, Illinois will serve as the third party data validator. As such, she will remain independent of direct job involvement and day-to-day operations, and have direct access to corporate executive staff, as necessary, to resolve QA disputes. The data validator will be responsible for auditing the implementation of the QA program in conformance with the demands of specific investigations, O'Brien & Gere's policies, and USEPA requirements. The specific functions include:

- Providing QA audits on various phases of the field operations
- Reviewing and approving the QA plans and procedures
- Reporting on the adequacy, status, and effectiveness of the QA program on a regular basis to the Solutia RPM
- Data validation of all sample results from the analytical laboratory.

2.3.2. O'Brien & Gere QA officer

Karen Storne will serve as the O'Brien & Gere QA Officer (QAO). As such, she will report directly to the O'Brien & Gere PM and will be responsible for verifying that all O'Brien & Gere QA procedures for this project are being followed. In addition, she will be responsible for internal laboratory audits.

2.3.3. USEPA Region V quality assurance reviewer

Michael McAteer, the USEPA Region V RPM, or a designee, will serve as the USEPA Region V Quality Assurance Reviewer. As such, he will have the responsibility to review and approve the QAPP. In addition, he will be responsible for conducting external performance and system audits of the

laboratory and field activities, and reviewing and evaluating analytical laboratory and field procedures.

2.4. Field responsibilities

2.4.1. O'Brien & Gere field leader

David E. Haverdink, or a designee, will serve as the O'Brien & Gere Field Leader. He will be responsible for leading, coordinating, and supervising the day-to-day field activities. His responsibilities include:

- Provision of day-to-day coordination with the O'Brien & Gere PM on technical issues
- Develop and implement field-related sampling plans and schedule
- Coordinate and manage field staff
- Supervise or act as the field sample custodian
- Implement the QC for technical data, including field measurements
- Adhere to work schedules
- Authorize and approve text and graphics required for field team efforts
- Coordinate and oversee technical efforts of subcontractors assisting the field team
- Identify problems at the field team level, resolve difficulties in consultation with the O'Brien & Gere PM, implement and document corrective action procedures, and provide communication between team and upper management
- Prepare the final report.

2.4.2. O'Brien & Gere field team

The technical staff (William E. Wright and Joseph W. Perry) will be drawn from O'Brien & Gere's pool of corporate resources. The technical staff will be utilized to gather and analyze data, and to prepare various task reports and support materials. The technical staff are experienced

professionals who possess the degree of specialization and technical competence required to effectively and efficiently perform the required work.

2.5. Laboratory responsibilities

2.5.1. Laboratory project manager

Elizabeth F. Beauchamp will serve as the Savannah Labs PM, and John Guenther will serve as the Triangle Labs PM. As such, they will report directly to the O'Brien & Gere PM and will be responsible for the following:

- Ensuring the resources of the laboratory are available on an as-required basis
- Reviewing the final analytical report
- Approving final analytical reports prior to submission to the O'Brien & Gere PM.

2.5.2. Laboratory operations manager

C. Henry Beauchamp will serve as the Savannah Labs Operations Manager (OM), and Valerie Evans will serve as the Triangle Labs OM. As such, they will report to their respective Laboratory PM and will be responsible for:

- Coordinating laboratory analysis
- Supervising in-house chain-of-custody
- Scheduling sample analysis
- Overseeing data review
- Overseeing preparation of analytical reports
- Approving final analytical reports.

2.5.3. Laboratory quality assurance officer

Kirstin McCracken will serve as the Savannah Labs QAO, and Donald Haraven will serve as the Triangle Labs QAO. As such, they will have overall responsibility for data after it leaves the analyst and before it leaves the laboratory. The Laboratory QAO will be responsible for the following:

- Overviewing laboratory quality assurance
- Overviewing QA/QC documentation
- Conducting detailed data review
- Deciding whether to implement laboratory corrective actions, if required
- Defining appropriate laboratory QA procedures
- Preparing laboratory standard operation procedures (SOPs)
- Approving the laboratory QAPP.

2.5.4. Laboratory sample custodian

Elizabeth Sicay will serve as the Savannah Labs Sample Custodian, and Bill Hurst and David Chu will serve as the Triangle Labs Sample Custodians. As such, they will report to their respective Laboratory OM. Their responsibilities will include the following:

- Receiving and inspecting the incoming sample containers
- Recording the condition of the incoming sample containers
- Signing appropriate documents
- Verifying the chain-of-custody and its correctiveness
- Notifying the Laboratory PM of sample receipt and inspection
- Assigning a unique identification number and entering each into the sample receiving log
- Controlling and monitoring access and storage of samples.

Final responsibility for the project quality rests with the O'Brien & Gere PM. Independent quality assurance will be provided by each Laboratory PM and Laboratory QAO prior to release of all data to O'Brien & Gere.

2.5.5. Laboratory technical staff

The Savannah Labs and Triangle Labs technical staff will be responsible for sample analysis and identification of corrective actions. The staff will report directly to their respective Laboratory OM.

3. Quality assurance objectives for measurement

The overall QA objective for this SSP is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide results which are legally defensible in a court of law. Specific procedures for sampling, chain-of-custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal quality control, audits, preventive maintenance of field equipment, and corrective action are described in other sections of this QAPP.

The control limits for precision and accuracy to be used for each laboratory analysis in this SSP are listed in Tables 6A through 6N. The analytes and detection limits for each analysis are listed in Tables 5A through 5P.

3.1. Precision

3.1.1. Definition

Precision is a measure of the degree to which two or more measurements are in agreement

3.1.2. Field precision objectives

Field precision is assessed through the collection and measurement of field duplicates at a rate of one duplicate per ten analytical samples. The total number of duplicates for this SSP are found in Table 2. Precision control limits are presented in Tables 6A through 6N.

3.1.3. Laboratory precision objectives

Precision in the laboratory is assessed through the calculation of relative percent differences (RPD) and relative standard deviations (RSD) for two or more replicate samples. The equations to be used for precision in this SSP are presented in Chapter 12 of this QAPP. Precision control limits are presented in Tables 6A through 6N.

3.2. Accuracy

3.2.1. Definition

Accuracy is the degree of agreement between an observed value and an accepted reference value.

3.2.2. Field accuracy objectives

Accuracy in the field is assessed through the use of field and trip blanks and through the adherence to all sample handling, preservation, and holding times. Accuracy control limits are presented in Tables 6A through 6N.

3.2.3. Laboratory accuracy objectives

Laboratory accuracy is assessed through the analysis of matrix spikes (MS), standard references, or laboratory control samples (LCSs), and the determination of percent recoveries. The equation to be used for accuracy in this SSP is presented in Chapter 12 of this QAPP. Accuracy control limits are presented in Tables 6A through 6N.

3.3. Completeness

3.3.1. Definition

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions.

3.3.2. Field completeness objectives

Field completeness is a measure of the amount of valid measurements obtained from all the measurements taken in the project. Field completeness for this project will be greater than 90 percent. In the event that the field completeness target of greater than 90 percent is not achieved, additional samples will be collected and analyzed so that the 90 percent goal will be achieved.

3.3.3. Laboratory completeness objectives

Laboratory completeness is a measure of the amount of valid measurements obtained from all the laboratory measurements taken in the project. The equation for completeness is presented in Chapter 12 of this QAPP. Laboratory completeness for this project will be greater than 95 percent. In the event that the laboratory completeness target of greater than 95 percent is not achieved, additional samples will be collected and analyzed so that the 95 percent goal will be achieved.

3.4. Representativeness

3.4.1. Definition

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

3.4.2. Measurement to ensure representativeness of field data

Representativeness is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the SSP and FSP are followed and that proper sampling techniques are used.

3.4.3. Measures to ensure representativeness of laboratory data

Representativeness in the laboratory data is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing the field duplicated samples. The sampling network is designed to provide data representative of site conditions. During development of this network, consideration is given to existing analytical data, past site practices, and physical setting and processes. The rationale of the sampling network is discussed in the SSP.

3.5. Comparability

3.5.1. Definition

Comparability is an expression of the confidence with which one data set can be compared with another. Comparability is also dependent on similar QA objectives.

3.5.2. Measures to ensure comparability of field data

Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the SSP and FSP are followed and that proper sampling techniques are used.

3.5.3. Measures to ensure comparability of laboratory data

Planned analytical data will be comparable when similar sampling and analytical methods are used and documented in the QAPP. Comparability is also dependent on similar QA objectives.

3.6. Sensitivity

3.6.1. Definition

Sensitivity refers to a measurable concentration of an analyte which has an acceptable level of confidence.

3.6.2. Measures to ensure comparability of laboratory data

Sensitivity is measured though the determination of detection limits for each analytical method. Method detection limits (MDLs) are the lowest concentration of an analyte that can be measured with 99% confidence that the analyte concentration is greater than zero. Practical quantitation limits (PQLs) are levels above the MDLs at which the laboratory has demonstrated the quantitation of analytes. The sensitivity of the analytical methods is dependent upon whether the methods associated with this project have PQLs and MDLs at sufficiently low levels to adequately assess the project DQOs. Field sampling personnel, the analytical laboratory, the data validator and risk assessors (human health and ecological) will work together on a frequent and regular basis to ensure that PQLs are as low as feasible for the media being sampled and that sample analytical results will achieve data quality levels (DQLs) within the limits of the selected analytical method. The PQLs and MDLs are presented in Tables 5A through 5P. The PQLs for waste samples that are to be prepared using the USEPA TCLP procedures and that are analyzed for VOCs, SVOC, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxins and dibenzofurans, are the same as the PQLs presented for VOCs, SVOC, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxins and dibenzofurans. The PQLs and MDLs presented in the VOC table for soil are based on USEPA Method 5035 preparation procedure.

3.7. Level of quality control effort

Field blanks, trip blanks, method blanks, duplicates, reference standards, and spike samples will be analyzed to assess the quality of the data resulting from the field sampling and analytical programs.

The following are the field and laboratory QA/QC measures used to evaluate data quality.

A field blank (or equipment blank) must be submitted to the laboratory with the investigative samples and analyzed for the same parameters as the investigative samples with the exception of soil gas and air samples. Field blanks consist of organic-free and inorganic-free water which is poured over cleaned sampling equipment in between sample collections. Field blanks are analyzed to check for procedural contamination at the site which may cause sample contamination. The minimum required is one per every ten samples or one per sampling day if less than ten samples are collected, unless dedicated sampling equipment is used to collect samples.

A trip blank must be included in each cooler which contains VOC samples and is analyzed by the laboratory for volatile organic compounds (VOCs) for all sites at which VOC (soil or water) is one of the analytical parameters. The trip blank consists of organic-free water placed in one VOC vial, which is transported to the sampling site unopened, stored with the investigative samples, and kept closed until analyzed by the laboratory. Trip blanks are used to assess the potential for VOC contamination of samples due to constituent migration during sample shipment. One trip blank is required for each shipping container which contains samples collected for VOC analysis.

Method blanks are used to assess contamination resulting from the laboratory procedures. The laboratory must run a method (preparation) blank at the beginning of each analytical run for each day that the analysis is preformed. If not all samples analyses are completed in one day, a minimum of one method blank per sample matrix per analytical method must be run at the beginning of each sample batch analyzed each day.

Field duplicates must be provided for each matrix sampled. Field duplicate samples are analyzed as a check of sampling and analytical reproducibility; laboratory duplicates provide an estimate of the reproducibility of

measurement. The field duplicate will be analyzed for all parameters for which the investigative samples of that matrix are analyzed. The minimum number of field duplicates required is one per every ten samples or, if there are fewer than ten samples, one per matrix.

Matrix spikes (MSs) provide information about the effect of the sample matrix or digestion and measurement methodology. MSs for organic analyses will be performed in duplicate (MSD). The spike duplicate will be performed for inorganic analyses. MS or spike duplicate samples will be collected at a frequency of one for every twenty samples collected, or, if fewer than twenty samples per matrix, one for each matrix sampled. The MS/MSD and spike duplicate is an investigative sample which (for each applicable analytical parameter for that sample matrix) is split by the laboratory, spiked with target analytes for that analytical procedure, and analyzed with the other samples of that matrix. Samples chosen as MS/MSD and spike duplicates should be selected prior to the sampling event so that sufficient sample volume is acquired.

Laboratory control samples (LCSs) are standard solutions that consist of known concentrations of the target analytes spiked into laboratory organic-free distilled water or clean sand. They are prepared or purchased from a source independent from the calibration standards to provide an independent verification of the calibration procedure. They are spiked with all target analytes for each analysis. These QC samples are then prepared and analyzed following the same procedures employed for environmental sample analysis to assess method accuracy independently of sample matrix effects. The laboratory will prepare and analyze an LCS with each group of twenty samples of similar matrix that are extracted, digested, or analyzed at the same time (within same 12-hr period) for gas chromatograph/mass spectrometer (GC/MS) analysis. Percent recoveries will be evaluated using laboratory established control limits to assess the efficiency of preparation and analysis method independent of environmental sample matrix effects.

Upon initiation of an analytical run, the laboratory must perform calibration procedures as instructed by the analytical methods used. During the length of the run, calibration verifications must be performed at the frequency specified to verify the initial calibration.

Surrogates must be added to all samples for organic analysis. Surrogate recovery will be used to assess accuracy of organic analyses.

Control limits are the maximum and/or minimum values which define a range for a specific parameter, as outlined within each analytical procedure, at which sample results are considered to satisfactorily meet quality control

criteria. When the parameter falls outside that range, the procedure is considered to be out-of-control. Whenever the analytical procedure is or becomes out-of-control, corrective action must be taken to bring the analysis back into control. The corrective action must include:

1. Finding the cause of the problem
2. Correcting the problem
3. Demonstrating the problem has been corrected by reanalyzing appropriate laboratory reference samples
4. Repeating the analysis of any investigative samples that may have been affected by the control problem.

Exceptions will be made on a case-specific basis. Documentation must include evidence that a good-faith effort was made to meet the control limit; this may include two attempts to analyze the sample.

The level of QC effort provided by the laboratory will be equivalent to the level of QC effort specified in the methods listed in Table 3.

The following are the field equipment QC efforts for the project.

All field analytical equipment will be calibrated immediately prior to each day's use, in the middle of the day (approximately every four hours), and more frequently if required. The calibration procedures will conform to manufacturer's standard instructions. This calibration will ensure that the equipment is functioning within the allowable tolerances established by the manufacturer and required by the project. Records of all instrument calibration will be maintained by the O'Brien & Gere PM and will be subject to audit by the O'Brien & Gere QAO. Copies of all of the instrument manuals will be maintained on-site by the O'Brien & Gere Field Leader.

The level of QC effort for the field measurement of pH involves calibration of the pH meter which will be performed immediately prior to each day's use, in the middle of the day (approximately every four hours), and more frequently if required. National Institute of Standards and Technology (NIST)-traceable standard buffer solutions which bracket the expected pH range will be used. The standards will most likely be pH of 7.0 and 10.0 standard units. The use of the pH calibration and slope knobs will be used

to set the meter to display the value of the standard being checked. The calibration data will be recorded on calibration sheets maintained on-site.

The QC effort for field turbidity measurements will include calibration checks using the turbidity standard which will be performed immediately prior to each day's use, in the middle of the day (approximately every four hours), and more frequently if required. The portable turbidity meter will be calibrated using a reference solution specified by the manufacturer. Readings must be within 10 percent to be acceptable.

The QC effort for field conductivity measurements will include calibration checks using the conductivity standard which will be performed immediately prior to each day's use, in the middle of the day (approximately every four hours), and more frequently if required. The portable conductivity meter will be calibrated using a reference solution specified by the manufacturer. Readings must be within 5 percent to be acceptable.

The QC effort for photoionization detector (PID) measurements will include calibration checks using calibration gas which will be performed immediately prior to each day's use, in the middle of the day (approximately every four hours), and more frequently if required.

The QC effort for field gas chromatograph measurements will include development of a three- or five-point calibration curve, analysis of a method blank at the start of each day and at the rate of one per every ten samples collected, and through the performance of continuing calibration checks at the start of each day and at a rate of one per every ten samples collected to verify that operation of the measurement system is in control and not varying.

The QC effort for explosimeter measurements will be maintained by using a simultaneous zero calibration and span calibration procedure as outlined in Appendix C of this document.

The QC effort for real-time aerosol monitor (RAM) measurements will be maintained by using an internal calibration method installed by the factory when the instrument is manufactured. The factory calibrates the instrument to the standard ISO 12103-1, A1 test dust. The calibration data is stored internally and cannot be accessed. This standard test dust is used because of its wide particle size distribution which makes the internal calibration representative of an average of most types of ambient aerosol that may be encountered.

The QC effort for magnetometer measurements will include calibration of the magnetometer to an approximate value based on established magnetic intensity for the region available in reference documents. Additionally, quality control will be maintained by visually inspecting the data as they are acquired. If the equipment signals a data collection problem during measurement of data, the measurement point is recollected.

4. Sample procedures

The following sampling procedures and practices that will be used in the SSP are presented in the FSP and in the Health and Safety Plan (O'Brien & Gere Engineers, Inc., 1999):

- Ground water sampling
- Soil sampling
- Surface water and sediment sampling
- Air sampling
- Monitoring well installation
- Sample custody procedures
- Decontamination procedures.

The sample identification system will involve the following:

- Soil gas survey data will be labeled SG-G-1 where "SG" denotes soil gas survey, "G" is the site designation, and "1" denotes a sequential sample number.

- Waste samples will be labeled WASTE-G-___FT where "WASTE" denotes a waste sample, "G" is the site designation, and "___FT" indicates sample depth, which is filled in by the sampler.

- Fill area and upgradient ground water samples will be labeled using the well name (*e.g.*, EEG-107)

- Alluvial aquifer samples will be labeled AA-I-S1-___FT where "AA" denotes an alluvial aquifer sample, "I" is the site designation, "S1" is the sequentially numbered sampling station, and "___FT" indicates sample depth, which is filled in by the sampler.

- Bedrock ground water samples will be labeled BR-1 and BR-2 where "BR" denotes a bedrock ground water sample and "1" and "2" denote sequential numbers.

- Shallow ground water samples will be labeled SGW-S1-___FT where "SGW" denotes a shallow ground water sample, "S1" is the sequentially

numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Time series ground water samples will be labeled TS-S1-___HR where "TS" denotes a time series sample, "S1" is the sequentially numbered sampling location, and "___HR" indicates sample time, which is filled in by the sampler.

- Domestic well samples will be labeled DW-ABCD-1 where "DW" denotes a domestic well sample, "ABCD" denotes the first four letters of the well owner's last name, and "1" denotes a sequential sample number.

- Undeveloped area soil samples will be labeled UAS-T1-S1-___FT where "UAS" denotes an undeveloped area soil sample, "T1" is the transect number, "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Developed area soil samples will be labeled DAS-T1-S1-___FT where "DAS" denotes a developed area soil sample, "T1" is the transect number "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Background soil samples will be labeled BS-EE20-___FT where "BS" denotes a background soil sample, "EE20" is the well location adjacent to the soil sample, and "___FT" indicated sample depth, which is filled in by the sampler.

- Undeveloped area sediment samples will be labeled BSSED-CSA-S1-___FT where "BSSED" denotes a broad-scan sediment sample, "CSA" designates Dead Creek sector, "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Developed area sediment samples will be labeled FASED-CSA-S1-___FT where "FASED" denotes a focused analysis sediment sample, "CSA" designates Dead Creek sector, "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Borrow Pit Lake sediment samples will be labeled "BPLSED-S1-___FT where "BPLSED" denotes a sediment sample from Borrow Pit Lake, "S1" is the sequentially numbered sampling location and "___FT" indicates sample depth, which is filled in by the sampler.

- Dead Creek sediment samples will be labeled SED-CSA-S1-___FT where "SED" denotes a sediment sample, "CSA" designates the Dead Creek sector, "S1" is the sequentially numbered sampling location, and "___FT" indicates sample depth, which is filled in by the sampler.

- Surface water samples will be labeled SW-CSA-S1 or SW-BPL-S1, where "SW" denotes a surface water sample, "CSA" or "BPL" designate Dead Creek sector or Borrow Pit Lake, respectively, and "S1" is the sequentially numbered sampling location.

- Air samples will be labeled AIR-V-1, AIR-S-1, or AIR-M-1 where "AIR" denotes an air sample, "V", "S", or "M" designate a VOC, SVOC, or metals sample, respectively, and "1" denotes a sequential sample number.

- Incineration pilot test samples will be labeled WI-G-1 where "WI" denotes a waste sample for incineration testing, "G" is the site designation, and "1" denotes a sequential sampling number.

- Waste thermal desorption pilot test samples will be labeled WTD-G-1 where "WTD" denotes a waste sample for thermal desorption testing, "G" is the site designation, and "1" denotes a sequential sample number.

- Sediment thermal desorption pilot test samples will be labeled STD-CSB-1 and STD-M-1 where "STD" denotes a sediment sample for thermal desorption testing, "CSB" or "M" designates Dead Creek Sector B or Site M, respectively, and "1" denotes a sequential sample number.

- Sediment stabilization pilot test samples will be labeled SS-S1-1 where "SS" denotes a sediment sample for stabilization testing, "S1" is the sequentially numbered sampling station, and "1" denotes a sequential sample number.

- Leachate pilot test samples will be labeled LEACH-I-1 where "LEACH" denotes a leachate sample for testing, "I" is the site designation, and "1" denotes a sequential sample number.

- "MS/MSD" or "DUP" at the end of a sample identification will indicate a matrix spike/matrix spike duplicate/spike duplicate or a duplicate sample, respectively.

Table 3 lists the sample volumes suggested for wastes, soil, ground water, surface water, sediment, and air samples collected for this project, as well as the holding times, the proper containers, and the required preservation.

Instructions for collecting QC sample for each matrix, including field duplicates, field blanks, MS/MSDs, and spike duplicates are described in the FSP.

Care should be taken that sufficient sample volume is provided for all necessary analyses to be performed. This applies to field blanks, field duplicates, and MS/MSD/spike duplicate samples as well as for investigative samples. This is most easily accomplished by specifying that samples are collected in specific sizes and types of containers which provide sufficient volume (and meet other necessary criteria) for the particular types of analyses that will be performed. Samples designated for use as the MS/MSD require double volume for organic analysis. For example, if a particular sample matrix is to be submitted for VOCs, then the sample designated as the MS/MSD will require four 40 mL vials rather than the usual two.

Pre-cleaned sample containers will be purchased from Scientific Specialties, which is a USEPA-certified manufacturer that uses USEPA Region X directive R10CONT01.0 to clean the sample containers, or from Savannah Labs which certifies containers in accordance with SOP CU35: Procedures for contaminant-free containers.

Proper sample packaging and shipping procedures to be used are presented in Chapter 5 of this QAPP.

Trip blank preparation is described in section 3.7 of this QAPP.

Field measurements will be performed in accordance with the USEPA methods listed in Table 2.

Preventive maintenance is discussed in Chapter 11 of this QAPP.

5. Custody procedures

Chain-of-custody procedures will be instituted and followed throughout the investigation. Custody is one of several factors necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory activities, and final evidence files. Final evidence files, including all originals of laboratory reports and purge files, are maintained under document control in a secure area. Samples are physical evidence and will be handled according to strict chain-of-custody protocols. The O'Brien & Gere QAO must be prepared to produce documentation that traces the samples from the field to the laboratory and through analyses. The USEPA has defined custody of evidence as follows:

- In actual possession
- In view after being in physical possession
- In a locked location
- In a designated, secure, restricted area.

5.1. Field custody procedures

The field sampler is personally responsible for the care and custody of the sample until transferred. In the field sampler's individual bound field notebook, samplers will note, with permanent ink, meteorological data, equipment employed for sample collection, calculations, information regarding collection of QA/QC samples, and any observations. All entries will be signed and dated, and any entry which is to be deleted shall use a single cross-out which is signed and dated. The following physical information will be recorded in the field notebook by the field sampling team:

- Sample number
- Project identification

- Sampling location
- Required analysis
- Date and time of sample collection
- Type and matrix of sample
- Sampling technique
- Preservation used if applicable
- Sampling conditions
- Observations
- Initials of the sampler.

The following information will be recorded on the chain-of-custody by the field sampling team:

- Project identification and number
- Sample description/location
- Required analysis
- Date and time of sample collection
- Type and matrix of sample
- Number of sample containers
- Analysis requested/comments
- Sampler signature/date/time.
- Air bill number.

A completed sample tag (attached with adhesive) and sample label (attached with wire), which is shown in Figure 4, will each be attached to each investigative or QC sample and the sample placed in a shipping container. The sample tag and sample label are identical. Two sample custody seals (shown in Figures 5 for Savannah Laboratories and in Figure 6 for Triangle) will be applied to coolers. The following will be recorded with permanent ink on sample tags, on sample labels, and on chain-of-custody records by the field sampling team:

- Project name and number
- Sample number identification
- Initials of sampler
- Sampling location (if not already encoded in the sample number)
- Required analysis
- Date and time of sample collection
- Space for laboratory sample number (only on the sample tag)
- Preservative used, if applicable.

The sample identification system to be used in the field is described in Chapter 4 of this QAPP.

The field sampling team will send the coolers to Savannah Labs. For samples collected for dioxin and dibenzofuran analysis, samples will be sent to Triangle Labs. Samples will not be sent to another laboratory without the permission of USEPA Region V.

The laboratory will assign a number for each sample upon receipt. That sample number will be placed on the sample tag and sample label. The sample label will be attached to the sample container. The sample tag will be attached to the chain-of-custody.

A chain-of-custody document providing all information, signatures, dates, and other information, as required on the example chain-of-custody form in Figure 2, will be completed by the field sampler and provided for each sample cooler. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the chain-of-custody. The field sampler will sign the chain-of-custody record when relinquishing custody, make a copy to keep with the field logbook, and include the original form in an air-tight plastic bag in the sample cooler with the associated samples. Sampling containers will be packed in styrofoam sheets and put in plastic bags to help prevent breakage and cross-contamination. Samples will be shipped in coolers, each containing a chain-of-custody and ice and ice packs to maintain inside temperature at approximately 4°C. Sample coolers will then be sealed between the lid and sides of the cooler with two custody seals prior to shipment. The custody seals will consist of adhesive-backed tape that easily rips if it is disturbed. Samples will be shipped to the laboratory by common overnight carrier or will delivered by O'Brien & Gere.

Samples will remain in the custody of the sampler until transfer of custody is completed. Transfer consists of:

- Delivery of samples to the laboratory sample custodian
- Signature of the laboratory sample custodian on the chain-of-custody document as receiving the samples and signature of sampler as relinquishing the samples.

If a carrier is used to take samples between the sampler and the laboratory, a copy of the air bill must be attached to the chain-of-custody to maintain proof of custody, and the air bill number must be written on the chain-of-custody.

5.2. Laboratory custody procedures

Laboratory custody procedures begin when the samples are received by the laboratory. When the samples arrive at the laboratory, either the mail room custodian or the sample custodian (identified in Chapter 2) will sign the vendor's air bill or bill of lading (unless hand-delivered) and the chain-of-custody. The sample custodian's duties and responsibilities upon sample receipt will be to:

- Document receipt of samples
- Inspect sample shipping containers for the presence or absence of custody seals (only if shipped via overnight courier) and for container integrity
- Check the cooler temperature and record on the chain-of-custody. If the cooler temperature is greater than 10°C, the O'Brien & Gere QAO will be contacted
- Sign and date the appropriate forms or documents, verify and record the agreement or disagreement of information on sample documents, and, if there are discrepancies, record the problem and notify the Laboratory QAO
- Log sample information into the laboratory sample tracking system, including:
    - date and time of sample receipt
    - project number
    - field sample number
    - laboratory sample number (assigned during log-in procedure)
    - sample matrix
    - sample parameters
    - storage location
    - log-in person's initials
- Label sample with a unique, sequential laboratory sample number

- Place samples in the walk-in cooler, or sample storage area which is a secure, limited-access storage. The samples collected for volatile analysis will be stored in a separate refrigerator.

At the laboratory, the analysts will be required to log samples and extracts in and out of storage as the analysis proceeds. An example of the laboratory internal chain-of-custody form is provided as Figure 3. Samples and extracts will be returned to secure storage at the close of business. Written records will be kept of each time the sample or extract changes hands. Care must be exercised to properly complete, date, and sign items needed to generate data.

The following procedures must be followed by the laboratory:

- Samples will be handled by the minimum number of people possible.
- The laboratory will set aside a secured sample storage area consisting of a clean, dry, refrigerated, isolated room, which is capable of being locked.
- A specific person will be designated sample custodian. Incoming samples must be received by the custodian who will indicate receipt by signing the chain-of-custody form.
- The custodian will ensure that samples which are heat-sensitive, light-sensitive, radioactive, or which require special handling in other ways, are properly stored and maintained prior to analysis.
- The analytical area will be restricted to authorized personnel only.
- After sample analyses are complete, the laboratory may discard sample one month after the date on the final report. Analytical data is to be kept secured and released to authorized personnel only.

5.3. Final evidence file chain-of-custody procedures

The final evidence file will be the central repository for documents which constitute evidence relevant to sampling and analysis activities as described in this QAPP. O'Brien & Gere is the custodian of the evidence file and maintains the contents of evidence files for the site, including relevant records, reported, logs, field notebooks, pictures, subcontractor reports, and data reviews.

Copies of the following will be stored by the laboratory for incorporation into the sample file; the Laboratory OM will be responsible for final evidence documentation assembly:

- Documentation of the preparation and analysis of samples, including copies of the analysts' notebooks
- Bench sheets, graphs, computer printouts, chromatograms, and mass spectra, as applicable
- Copies of QA/QC data
- Instrument logs showing the date, time, and identity of the analyst
- Analytical tracking forms that record the date, time, and identity of the analyst for each step of the sample preparation, extraction, and analysis.

Upon completion of the analyses, the O'Brien & Gere QAO will begin assimilating the field and laboratory notes. In this way, the file for the samples will be generated. The final file for the sample will be stored at O'Brien & Gere and will consist of the following:

- Laboratory data packages, including summary and raw data from the analysis of environmental and QC samples, chromatograms, mass spectra, calibration data, work sheets, and sample preparation logs
- Chain-of-custody records
- Data validation reports.

The following documentation will supplement the chain-of-custody records:

- Field notebooks and data
- Field collection report
- Pictures and drawings
- Progress and QA reports
- Contractor and subcontractor reports
- Correspondence.

The evidence file must be maintained in a secured, limited access area until submittals for the project have been reviewed and approved, and for a minimum of six years past the submittal date of the final report.

6. Calibration procedures and frequency

Calibration is a reproducible reference point in which all sample measurements can be correlated. A sound calibration program shall include provisions for documentation of frequency, conditions, standards, and records reflecting the calibration history of a measurement system. The accuracy of the calibration standard is important because all data will be in reference to the standards used.

Proper calibration of laboratory analytical instrumentation and field instrumentation is essential for the generation of reliable data which meets the project's DQOs. Analytical instrument calibration is monitored through the use of control limits which are established for individual analytical methods. Calibration procedures to be followed are specified, in detail, in the analytical methods listed in Table 2. These procedures specify the type of calibration, calibration materials to be used, range of calibration, and frequency of calibration. For field analyses, calibrations must be performed and documented on the instrumentation used.

6.1. Field equipment calibration

Field equipment that will be used to collect data on conductivity, pH, turbidity, temperature, organic vapors, soil gas, on-site dust concentrations, explosive atmospheres, and magnetic anomalies will be calibrated in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications.

Field instruments to be used that require calibration include, but are not limited to, the following:

- Hydac® pH, temperature, and conductivity meter
- Turbidity meter
- HNu® PL-101 or DL-101 PID
- Photovac MicroTIP® detector
- Field gas chromatograph

- Neotronics Mini Gas 4® Portable 4-in-1 Multi-Gas Monitor (explosimeter)
- Dusttrak® Model 8520 RAM or equal
- Geometrics 858 Cesium or 856AX TOTAL Field Magnetometer.

Equipment to be used for the field sampling will be examined to confirm that it is in good operating condition. This includes checking the manufacturer's operating manual and the instructions for each instrument to confirm that the maintenance requirements are being observed. Field notes from previous sampling trips will be reviewed so that the notations on any prior equipment problems are not overlooked, and all necessary repairs to equipment have been carried out. Spare parts, including a spare pH meter electrode and a second thermometer, will be sent to the sampling locations.

In general, instruments will be calibrated immediately prior to each day's use, in the middle of the day (approximately every four hours), and will be recalibrated as required. Where applicable, the linearity of the instrument will be checked by using a two-point calibration with reference standards bracketing the expected measurement. Instrument-specific operation manuals will be consulted if further detail is required. All calibration procedures performed will be documented in the field logbook.

6.1.1. pH meter calibration

The pH meter will be calibrated with standard buffer solutions before being taken into the field. In the field, the meter will be calibrated with two buffer solutions before use. The range of the buffer solutions will bracket the expected pH of the samples being measured. The following calibration procedure will be followed:

- Check that the temperature of the sample and buffer are the same
- Connect the pH electrode into the pH meter and turn on the pH meter
- Set the temperature setting based on the temperature of the buffer; place the electrode in the pH 7 buffer solution
- After the reading has stabilized, adjust the "ZERO" knob to display the correct value
- Repeat the procedure for the second buffer solution (pH 4)

- Repeat the previous two steps until both pH readings are within 0.1 units of the standards
- Place the pH electrode in the sample and record the pH as displayed
- Remove the pH electrode from the sample and rinse with distilled water
- Recalibrate the pH meter for each sampling location and if it starts giving erratic results.

The calibrations performed, standard used, and sample pH values are to be recorded in the field notebook.

6.1.2. Conductivity meter calibration

The Hydac® conductivity meter will be checked against known conductivity standards before being taken to the field. In the field, the instrument will be checked with traceable reference standards. The following calibration procedure will be followed:

- Fill the cup on the Hydac® with the NIST-traceable conductivity standard
- Set the temperature knob for the temperature of the standard solution
- Turn to the appropriate scale and set the instrument for the value of the calibration standard
- Rinse the electrode with distilled water.

All readings and calibrations should be recorded in the field notebook.

6.1.3. Turbidity meter calibration

The turbidity meter will be checked against known turbidity standards before being taken to the field. In the field, the instrument will be checked with a reference standard. The following calibration procedures will be followed:

Standard procedure for calibration of a turbidity meter.

- With the instrument OFF, check the mechanical zero adjustment on the meter face. Adjust for a zero reading if necessary.

- Turn the instrument ON and perform a battery check. Charge the battery pack if the meter indicates below the BATTERY CHECK area.

- Place the focusing template into the cell holder, press the 1.0 range switch, and adjust the zero control to obtain a zero nephelometric turbidity unit (NTU) reading.

- Remove the focusing template and insert a 0.75 NTU turbidity standard. Adjust the SPAN control for a corrected 0.75 NTU reading.

- Remove the 0.75 NTU standard and replace it with a 10 NTU standard. Press the 10 range switch. The meter should indicate 10 (±0.2) NTU. If it does not, the 10 range potentiometer needs adjustment as described in the range calibration procedure described below. Adjust the SPAN control for a reading of exactly 10 NTU.

- Remove the 10 NTU standard and replace it with the cell riser and 100 NTU standard. Press the 100 range switch. The meter should indicate 100 (±2) NTU. If it does not, the 100 range potentiometer needs adjustment as described in the range calibration procedure described below.

- Remove the 100 NTU standard and cell riser and insert the 10 NTU standard. Press the 10 NTU range switch. Adjust the SPAN control for a reading of exactly 10 NTU.

- Remove the 10 NTU standard and replace it with a 0.75 NTU standard. Press the 1.0 range switch. The meter should indicate the corrected value for the 0.75 NTU standard (±0.02). If it does not, the 1.0 range potentiometer needs adjustment as described in the range calibration procedure described below.

Procedure for range calibration of turbidity meter.

- With the instrument OFF, check the meter's mechanical zero adjustment. Adjust for zero reading if necessary.

- Turn ON and perform battery check. Charge the battery back if the meter indicated below the BATTERY CHECK area.

- Place the focusing template into the cell holder. Press the 1.0 range switch and adjust the SPAN control fully counter-clockwise.

- Adjust the ZERO control clockwise to obtain a reading of 0.05 NTU on the 1.0 scale.

- Adjust the SPAN control clockwise to obtain a reading of 0.15 NTU on the 1.0 scale. DO NOT alter the SPAN control setting for the remainder of this procedure.

- Remove the focusing template and insert the cell riser and 100 NTU Formazin turbidity standard. Cover the standard with the light shield and allow the meter to stabilize. Adjust the 100 range adjustment potentiometer to obtain a full scale reading.

- Remove the 100 NTU standard and cell riser and insert the focusing template into the cell holder.

- Press the 10 range switch and adjust the zero control for a zero reading.

- Remove the focusing template and substitute the 10 NTU Formazin standard. Cover with the light shield and allow the meter to stabilize. Adjust the 10 range adjustment potentiometer to obtain a full scale reading.

- Remove the 10 NTU standard and insert the focusing template.

- Press the 1.0 range switch and adjust the zero control for a zero reading.

- Remove the focusing template and insert the 0.75 NTU Formazin turbidity standard. Cover with the light shield and allow the meter to stabilize. Adjust the 1.0 range adjustment potentiometer to obtain a reading equal to the corrected NTU value determined when adding the turbidity of the diluted water to the normal value of the standard.

All readings and calibrations should be recorded in the field notebook.

6.1.4. HNu Model PL-101 PID calibration

- Connect the analyzer to the regulator and cylinder with a short piece of tubing. The calibration gas in the cylinder consists of a mixture of isobutylene and zero air. The regulatory sets and controls the flow rate of the gas at approximately 250 cc/min. DO NOT use the cylinder below 30 psig as readings below that level may deviate up to 10% from the rated value.

- With the SPAN setting and function switch at the same position as listed in the Application Data Sheet or Calibration Report, open the valve of the cylinder until a steady reading is obtained.

- If the reading is the same as the recorded data, the analyzer calibration for the original species of interest is correct. If the reading has changes, adjust the SPAN setting until the reading is the same.

- Shut off the cylinder as soon as the reading is established.

- Record and maintain this new SPAN setting. Then recalibrate the analyzer on the species of interest as soon as possible.

- Check analyzer recalibration immediately with small cylinder and reading recorded. This can be used later in the field.

All readings and calibrations should be recorded in the field notebook.

6.1.5. HNu Model DL-101 PID calibration

- Press the Calibrate key on the front panel. "Calibrate" appears on the LCD.

- Press ENTER. "Enter/Exit" ↓↑
  "Elec_Zero? Y
  appears on the LCD. The up and down arrows toggle between YES and NO. Answer YES to electronically zero the unit. This is the preferred method. Answer NO to calibrate using "hydrocarbon-free" air as a zero reference. In this case, negative readings are possible if the analyzer measures a cleaner sample when in service. Press ENTER. "Zeroing Unit" appears on the LCD.

- Display then prompts: CE/ENT/EXIT
  Conc = ___ppm
  Enter the concentration of the calibration gas.

- "Attach gas to prove and /ENTER/" appears on the LCD.

- "Press ENTER when Ready: xxxxppm" appears on the screen. The unit reads ppm based on the most recent calibration. When readings stabilize, press ENTER to complete the calibration process.

- "Calibrating...Please Wait" appears on the screen. In the Survey Mode the unit saves to the default calibration; the LCD reverts to the operation screen. In the other three modes, the display prompts:

  "1-10/ENT"

  "Save to Cal #"

  Assign a number to the calibration. The LCD reverts to the operation screen and begins analyzing.

All readings and calibrations should be recorded in the field notebook.

6.1.6. Photovac MicroTIP calibration

- Connect the supplied regulator to the space gas cylinder. Hand tighten the fittings.
- Open the valve on the gas bag by turning the valve stem fully counter clockwise.
- Attach the gas bag adapter nut to the regulator. Hand tighten the fittings.
- Turn the regulator knob counter clockwise about half a turn to start the flow of gas.
- Fill the gas bag about half full and close the regulator fully clockwise to turn off the flow of gas.
- Disconnect the gas bag from the adaptor and empty it. Flush the bag a few times with Span Gas and then fill it.
- Close the bag by turning the valve clockwise.
- Press SETUP and select the desired Cal Memory with the arrow keys and press ENTER. Press EXIT to leave SETUP.
- Press CAL and expose MicroTIP to zero gas. Press ENTER and MicroTIP sets the zero point.
- Enter the known Span Gas concentration and connect bag adapter to inlet.
- Press ENTER and MicroTIP sets sensitivity.

- MicroTIP is ready for use and fully calibrated when display reverts to normal. Remove Span Gas bag from inlet.

All readings and calibrations should be recorded in the field notebook.

6.1.7. Gas chromatograph for soil gas total VOC analysis calibration

Initial calibration.

- Prior to initiation of field activities, a four-point calibration will be completed for benzene, chloroform, trichloroethylene, and 1,1-dichloroethane.
- Prepare standards by diluting precise aliquots of each calibrant standard in methanol.
- Transfer a precise aliquot of the solution into a 40 mL VOC vial and allow to volatilize.
- Withdraw a precise aliquot (200-100 μL) of the gaseous calibrant and inject into a GC with a graduated, air-tight syringe.
- Develop the appropriate equation for each calibrant standard relating calibrant peak area and concentration.

Field calibration.

- Run a mid-level standard of each calibrant at the start of each day, following the procedures outlined above.
- Repeat every ten sample runs to account for variations in instrument performance (*i.e.*, retention time shifts, detector response) throughout the sampling period.
- Run syringe blanks after each sample which exhibits detectable levels of VOC.
- Run additional syringe blanks, if necessary, until GC baseline performance is achieved.

All readings and calibrations should be recorded in the field notebook.

6.1.8. Explosimeter calibration

The Neotronic Mini Gas 4 Portable 4-in-1 Multi-Gas Monitor will be calibrated according to the procedures outlined in Appendix C of this document. All readings and calibrations should be recorded in the field notebook.

6.1.9. Real-time aerosol monitor calibration

The RAM is factory-calibrated to the standard ISO 12103-1, A1 test dust (formerly Arizona Test Dust). The calibration data are stored internally and cannot be accessed. This standard test dust is used because of its wide particle size distribution. This makes the internal calibration representative of an average of most types of ambient aerosol encountered. All readings and calibrations should be recorded in the field notebook.

6.1.10. Magnetometer calibration

The magnetometer will be calibrated to provide approximate value based on the established magnetic intensity for the region. The assumed magnetic field intensity for the site area is 51,000 gammas (based on the 1973 US Navy Map in: Applications Manual for Portable Magnetometers, Breiner, 1973). The calibration procedure is explained in the appropriate owner's operation manual and will vary between instrument models. The precise value for the intensity of the earth's magnetic field at the site is not necessary to identify the location of buried drums.

Following the calibration of the instrument, a field check of the magnetometer readings will be conducted. Here, the instrument is held motionless and ten readings are recorded. Variations in the recorded value of + or - 1 gamma is acceptable. Adjustment in the height of the magnetometer sensor may be necessary to reduce the interference from surface debris; however, for the purpose of this investigation, a standard sensor height of 2 m will be assumed.

A continuous quality control program will be maintained by visually inspecting the data as they are acquired. The data are displayed in a digital

format and an electronic beep is used to signal if data collection problems have resulted during the measurement. If a problem is detected, the measurement point will be recollected. The survey will not be continued until the data integrity has been assured.

All readings and calibrations should be recorded in the field notebook.

6.2. Laboratory equipment calibration

The laboratory will be responsible for proper calibration and maintenance of laboratory analytical equipment. Calibration procedures are presented in the analytical methods and the laboratory SOPs. Tables 7A through 7I present the specific calibration criteria and the conditions that will require recalibration for each method. Calibration procedures for a specific laboratory instrument will consist of initial calibration, initial calibration verification, and continuing calibration verification. The SOP for each analysis, listed in Tables 4A and 4B, describes the calibration procedures, their frequency, acceptance criteria, and the conditions that will require recalibration. In all cases, the initial calibration will be verified using an independently prepared calibration verification solution. The laboratory maintains a sample logbook for each instrument which will contain the following information: instrument identification, date of calibration, analyst, calibration solutions, and the samples associated with the calibrations.

The USEPA calibration procedures and frequencies are specified in the USEPA organic and inorganic methods listed in Table 2.

The following subsections detail some of the calibration procedures outlined in the analytical methods and the laboratory SOPs.

6.2.1. Gas chromatography/mass spectrometry (GC/MS)

Before the GC/MS is calibrated, the mass calibration and resolutions of the instruments are verified by a 50 nanogram injection of 4-bromofluorobenzene (BFB) for VOCs. The tune must meet the ion abundance criteria specified in the analytical method. The system must be verified every 12 hours of analysis and when the instrument performance check solution fails to meet criteria. After re-tuning, the performance check solution is reanalyzed. Samples are not analyzed until tuning criteria are met.

An initial five-point or six-point calibration is performed for the target compounds prior to start-up and whenever system specifications change or if the continuing calibration acceptance criteria have not been met. A calibration curve is generated for unheated purge for water sample analysis. The relative response factors (RRFs) and % RSD of specific compounds must meet established criteria as specified in the method. If these parameters fail to meet criteria, corrective actions must be implemented and the initial calibration must be repeated.

A 50 μg/L concentration continuing calibration standard containing the target compounds is analyzed at the beginning of every 12-hour period following the GC/MS tune. This standard must meet specific QC limits listed in the method to verify that the initial five-point calibration is still valid.

The calibration standards will be USEPA- or NIST-traceable and are spiked with internal standards and surrogate compounds.

6.2.2. Gas chromatography

After determination of acceptable chromatograph resolution, detector sensitivity, and chromatographic performance, calibration curves are generated from the analysis of standards at known concentrations covering the dynamic range of each analysis group for the primary and confirmation columns. The lowest concentration calibration standard establishes the quantitation limit based on the final volume of the samples. Recalibration of initial standard curves are completed when method criteria are not compliant. Compounds of interest will have an RSD of the response factors of the initial standard curve of less than 20% and a correlation coefficient or coefficient of determination of greater than 0.99 before analysis may begin.

At the beginning of each new analysis sequence and every ten sample analyses (or 12-hour period), a mid-point standard must be analyzed to

verify continued calibration. For analysis to continue, the response for the analytes of interest must not vary by more than 15%. The laboratory will contact the Laboratory QAO if the grand mean exception is to be applied to sample data. In the event that calibration criteria are not met, a new calibration curve must be prepared for the compound.

The laboratory will calculate retention time windows for the standards on the GC columns and whenever a new GC column is installed.

If any of the calibration verification standards fall outside the daily retention time window, the system is out of control. The cause of the problem must be identified and corrected before sample analysis may resume.

6.2.3. Metals and inorganics

Instrument calibration for metal analyses is performed daily. A two-point calibration for inductively coupled plasma (ICP) analyses is performed. Five-point calibrations are performed for spectrophotometers and graphite furnace and a minimum of three calibrations are performed for ion chromatographs. The calibration curves must have correlation coefficients greater than or equal to 0.995. Calibration verification is monitored by analyzing a calibration verification standard and a calibration blank following calibration, every ten samples, and at the end of the analytical sequence. The calibration verification standard recovery must be within appropriate method criteria or the instrument must be resloped and, if necessary, recalibrated. The calibration blank must not contain target compounds at concentrations greater than the PQL or corrective actions are implemented.

To verify interelement and background corrective factors for inductively coupled argon plasma (ICAP) analysis, interference check samples A and B (ICSA and ICSAB) must be analyzed at the beginning and end of the analysis. The percent recoveries for ICS solutions must be within 80% to 120% or corrective actions must be implemented. In addition, for ICAP analyses, a serial dilution analysis must be performed per sample matrix. If the analyte concentration is greater than fifty times the method detection limit (MDL) in the original sample, a serial dilution (five-fold dilution) must agree within ten percent of the original determination. Detection

limits, interelement corrective factors, and linear ranges must be established at the frequency specified in the method.

6.3. Standards and solutions

The use of standard materials of a known purity and quality is necessary for the generation of reproducible data. The laboratory will monitor the use of laboratory materials including solutions, standards, and reagents. Standards and standard solutions are obtained from the USEPA or commercial vendors. Certificates of analysis are included with each standard by the vendor

Standards and standard solutions are verified prior to use. This verification may be in the form of a certification from the supplier. Standards may also be verified by comparison to a standard curve or another standard from a separate source. Standards are routinely checked for signs of deterioration, including unusual volume changes, discoloration, formation of precipitates, or changes in analyte response.

Solvent materials are also verified prior to use. Each new lot of solvent is analyzed to verify the absence of interfering constituents. Reagent and method blanks are routinely analyzed to evaluate possible laboratory-based contamination of samples.

6.4. Records

A records book will be kept for standards and will include the following information:

- Material name
- Control or lot number
- Purity and/or concentration
- Supplier/manufacturer
- Receipt/preparation date
- Recipient's/preparer's name
- Expiration date.

These records will be checked periodically as part of the laboratory internal laboratory controls review.

6.5. Calibration records

A bound notebook will be kept with each instrument that requires calibration. The notebook will contain a record of activities associated with QA monitoring and instrument repairs. These records will be checked during periodic equipment review and internal and external QA/QC audits.

7. Analytical procedures

Wastes, soil, ground water, surface water, sediments, and air samples collected for this project will be analyzed by Savannah Labs. Samples collected for dioxin and dibenzofuran analysis will be analyzed by Triangle Labs. The specific methods listed in Table 3 and SOPs that will be utilized by the laboratory for sample analysis are presented in Tables 4A and 4B. The individual analytes for each method are presented in Tables 5A through 5P. Table 3 presents the specific QC samples to be taken for each analysis on a matrix specific basis.

7.1. Field analytical procedures

The standardization and QA information for field measurements of pH, turbidity, conductivity, temperature, organic vapors, soil gas, on-site dust concentrations, potentially explosive atmospheres, and magnetic anomalies are described in Chapter 6 of this QAPP. A copy of the Health and Safety Plan and FSP have been submitted with the QAPP to expedite review and approval of these methods. Where appropriate, the methods to be used for these measurements are listed in Table 2.

7.2. Laboratory analytical procedures

For this SSP, Savannah Labs and Triangle Labs will follow USEPA Methods listed in Table 2 and the laboratory SOPs listed in Tables 4A and 4B.

The accuracy and precision of the analytical data generated by the laboratory will be determined through the analysis of duplicate samples, spiked samples, reference standard samples, laboratory control samples, and field and laboratory blank samples analyzed along with each set of environmental samples, where applicable.

Interferences will be identified and documented. When matrix interferences are noted during sample analysis, actions will be taken by the laboratory to achieve the specified detection limits. Samples may be diluted only if target or nontarget analytes generate responses in excess of the linear range of the instrument. The Laboratory QAO will document in the case narrative that the laboratory demonstrates good analytical practices in order to achieve the specified detection limits.

Standards and reference materials will be analyzed to determine analyte concentrations for comparison with expected concentrations to provide a measure of accuracy of the methods. For organic analyses, the accuracy of the method will be determined by spiking the sample matrix with analytes and surrogates. Percent recoveries of the spikes will be calculated and compared with control limits. A measure of precision will be obtained through the RPD between matrix spikes and matrix spike duplicates. Sampling precision will be evaluated based on the RPD of duplicate field samples. RPDs will be compared to established control limits.

The generated data will be input into the laboratory's database management system. Complete descriptions of analytical procedures to be used in the laboratory are described in the SOPs and in the laboratory's Quality Assurance Manual (QAM) as listed in Tables 4A and 4B.

7.2.1. List of project target compounds and laboratory detection limits
Tables 5A through 5P list the project target compounds, laboratory PQLs, and MDLs for samples to be used as reference during this investigation.

7.2.2. List of associated QC samples
Section 3.7 of this QAPP and Table 3 contain a listing of the associated QC samples for analytes and matrices.

8. Internal quality control checks

The overall effectiveness of a quality control program depends upon operating in the field and laboratory according to a program that systematically ensures the precision and accuracy of analyses by detecting errors and preventing their recurrence or measuring the degree of error inherent in the methods applied. This section describes specific quality control checks to be addressed for both field and laboratory analysis in order to comply with the requirements of the SSP.

8.1. Field quality control checks

QC procedures for pH, turbidity, conductivity, temperature, organic vapors, soil gas, on-site dust concentrations, potentially explosive atmosphere, and magnetic anomaly measurements will include calibrating the instruments as described in Chapter 6 of this QAPP, measuring duplicate samples, and checking the reproducibility of the measurements by taking multiple readings on a single sample or reference standard. The QC information for field equipment is stated in Chapter 6 of this QAPP. Section 3.7 of this QAPP discusses the QC samples (including trip blank, equipment blank, MS/MSD, spike duplicate, and field duplicate) that will be collected during the field investigation. Table 3 list the environmental and corresponding QC samples to be collected by analyses and matrix type.

Field sampling crews will be under direct supervision of the field sampling leader. Bound notebooks and appropriate data sheets will be used to document the collection of samples and data so that an individual sample or data set can be traced back to its point of origin, sampler, and type of sampling equipment. Sampling will be performed according to the methods provided in the FSP and this QAPP.

Assessment of field sampling precision and bias will be made by collecting field duplicates and field blanks for laboratory analysis.

8.2. Laboratory quality control checks

Tables 7A through 7I summarize the laboratory QC requirements, frequency, control limits, and laboratory corrective actions for each analytical method. In addition, the specific SOPs, as listed in Tables 4A and 4B, provide a description of the specific QC requirements.

All data obtained will be properly recorded. The data package will include a full deliverable package capable of allowing the recipient to reconstruct QC information and compare it to QC criteria, and perform data validation. Samples analyzed in nonconformance with the QC criteria will be reanalyzed by the laboratory.

A brief description of laboratory QA/QC analyses for organics and inorganics is contained in the following subsections.

8.2.1. Calibration

Compliance requirements for satisfactory instrument calibration are established to verify that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of analysis, and calibration verification and performance checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis.

8.2.2. Blanks

Several types of blanks will be analyzed by the laboratory. Corrective action procedures will be implemented and documented for blank analyses if target compounds are detected at concentrations greater than the acceptable criteria. The criteria for evaluation of blanks apply to any blank associated with a group of samples. If problems with a blank exist, data associated with the project must be carefully evaluated to establish whether or not there is an inherent variability in the data for the project, or if the problem is an isolated occurrence not affecting other data.

A reagent blank consists of organic-free distilled water and any reagents added to a sample during analysis only, or straight solvent. This type of

sample is analyzed to evaluate whether contamination is occurring during the analysis of the sample. A reagent blank is usually analyzed following highly contaminated samples to assess the potential for cross-contamination during analysis.

A method blank is organic-free water which undergoes the preparation procedures applied to a sample. These samples are analyzed to examine whether sample preparation and analysis techniques result in sample contamination. The laboratory will prepare and analyze a method blank with each group of twenty samples of similar matrix that are analyzed at the same time or one method blank per each 12-hour analytical sequence for GC/MS analysis.

Field and trip blanks will also be collected and submitted for laboratory analysis, where appropriate. Field and trip blanks will be handled in the same manner as environmental samples. Field and trip blanks are analyzed to assess contamination introduced during field sampling procedures and sample shipment, respectively.

8.2.3. Internal standards performance

Internal standards, which are compounds not found in environmental samples, will be spiked into blanks, samples, MS/MSDs, and LCSs at the time of sample preparation. Internal standards for polychlorinated dibenzodioxin (PCDD) and polychlorinated dibenzofuran (PCDF) analyses are used to quantitate target compounds and to correct for variability of sample preparation, cleanup, and analysis with respect to individual sample matrices. Internal standards must meet retention time and performance criteria specified in the analytical method or the sample will be reanalyzed.

8.2.4. Recovery standard

Recovery standards consist of two labeled PCDDs and PCDFs which are spiked into environmental samples, blanks, and QC samples prior to sample injection for PCDF and PCDD analyses. Recovery standards are used to monitor instrument performance by evaluating retention time shifts and are used to quantitate results of internal standards.

8.2.5. Surrogate recovery

Accuracy and matrix biases for individual samples are monitored for organic analyses using surrogate additions. Surrogates are compounds

similar in nature to the target analytes which are spiked into environmental samples, blanks, and quality control samples prior to sample preparation for organic analyses. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects due to such factors as interferences and high concentrations of analytes. Since the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective.

8.2.6. Laboratory control sample analyses

LCSs are standard solutions that consist of known concentrations of the target analytes spiked into laboratory organic-free distilled water or clean sand. They are prepared or purchased from a certified manufacturer from a source independent from the calibration standards to provide an independent verification of the calibration procedure. They are spiked with all target analytes. These QC samples are then prepared and analyzed following the same procedures employed for environmental sample analysis to assess method accuracy independently of sample matrix effects. The laboratory will prepare and analyze an LCS with each group of twenty samples of similar matrix that are analyzed at the same time or each 12-hour analytical sequence period for GC/MS analysis. Percent recoveries will be compared to laboratory control limits to assess the efficiency of preparation and analysis method independent of environmental sample matrix effects.

8.2.7. MS/MSD/spike duplicate samples

MS/MSD and spike duplicate analyses will be performed on environmental samples at a frequency of one per sample matrix and every twenty samples of similar matrix. Whenever possible, MS/MSD and spike duplicate samples will be prepared and analyzed within the same batch as the environmental samples. MS/MSD and spike duplicate samples will be spiked at the laboratory with all target analytes. MS/MSD and spike duplicate data are generated to determine long-term precision and accuracy of the analytical method with respect to sample matrices.

8.2.8. Laboratory duplicate or matrix spike duplicate samples

Laboratory duplicate or MSD analyses will be performed on environmental samples at a frequency of one per sample matrix and every twenty samples of similar matrix for inorganic analyses. Whenever possible, laboratory duplicate or MSD samples will be prepared and analyzed within the same batch as the environmental samples. Laboratory duplicate or MSD data are generated to determine long-term precision of the analytical method with respect to sample matrices.

8.2.9. Compound identification and quantitation

The objective of the qualitative criteria is to minimize the number of erroneous identifications of compounds. An erroneous identification can either be a false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present). The identification criteria can be applied much more easily in detecting false positives than false negatives. Negatives, or non-detected compounds, on the other hand represent an absence of data and are, therefore, much more difficult to assess. The objective for quantitative requirements is to maximize the accuracy of data and sensitivity of the instrument. Samples will be analyzed undiluted when technically feasible (due to carryover or instrument contamination) to maximize sensitivity and to meet QAPP guidance criteria. Samples must be reanalyzed at the appropriate dilution when concentrations exceed the linear calibration range to maximize accuracy.

8.2.10. Control limits

Laboratory control limits are established separately for each matrix type for each type of analysis. Laboratory control limits can be considered action limits. These limits are defined as ± three standard deviations of the mean and correspond to 99.7% confidence limits of a normal distribution curve. The laboratory will establish control limits for each analyte of concern using a minimum of twenty data points. Laboratory control limits may change since limits are minimally updated on a yearly basis with the addition of new data points.

The laboratory control limits used to assess data for this program will be summarized by the laboratory in the analytical report.

9. Data reduction, validation, reporting, and data management

For data to be scientifically valid, legally defensible, and comparable, valid procedures must be used to prepare these data. The following describes the data reduction, validation, and reporting procedures to be used for the laboratory data.

Data reduction is the process of converting raw analytical data to final results in proper reporting units. Data reporting is the detailed description of the data deliverables used to completely document the analysis, calibration, quality control measures, and calculations. Data validation is the process of qualifying analytical/measurement data on the performance of the field and laboratory quality control measures incorporated into the sampling and analysis procedures.

Specific laboratory procedures and instrumentation can be found in the QAM and/or SOPs listed in Tables 4A and 4B. The data production and reporting procedures described below will be employed at the laboratory.

All data generated through field activities and analyzed by the laboratory shall be reduced by the laboratory, reported to O'Brien & Gere, data validated, then reported to USEPA Region V.

9.1. Data reduction

9.1.1. *Field data reduction procedures*

Field data reduction procedures will be minimal in scope compared to those implemented in the laboratory. Only direct reading instrumentation will be employed in the field. The use of pH, conductivity, and turbidity meters, thermometers, PIDs, field gas chromatograph, RAMs, explosimeters, and magnetometers will generate some measurements directly read from the meters following calibration by the respective manufacturer's recommendations. Such data will be written into field notebooks immediately after measurements are taken. If errors are made, results will

be legibly crossed out, initialed, and dated by the field member, and corrected in a space adjacent to the original entry. Later, when the results forms are filled out, the O'Brien & Gere Field Leader will proof the forms to assess whether transcription errors have been made.

9.1.2. Laboratory data reduction procedures

Data reduction consists of manual and computer data reduction procedures and calculations. Computer data reduction procedures and calculations will be checked manually by the laboratory to verify that compound identification and quantitation adhere to method requirements. The laboratory will be responsible for maintaining a listing of computer-based data reduction programs which it uses for data reduction. Sample preparation or extraction logs will be used to document sample preparation information (for example, preparation weights, volumes, reagents). Instrument injection logs or bench sheets will also be maintained for each instrument. The equations that will be used in reducing data are those listed in the USEPA methods. Analytical results for soil samples shall be calculated and reported on a dry weight basis.

QC data will be compared to the method acceptance criteria. Data considered to be acceptable will be entered into the laboratory computer system. Data summaries will be sent to the Laboratory QAO for review. Unacceptable data shall be appropriately qualified in the project report. Case narratives will be prepared which will include information concerning data that fell outside acceptance limits, and any other anomalous conditions encountered during sample analysis. After the Laboratory QAO or Laboratory PM approves these data, they are considered ready for data validation.

Qualitative identification and quantitation of organic analytes will be performed by experienced analysts in accordance with analytical method requirements.

Analytical results are generally entered into the laboratory computer system by the analyst, independently reviewed by another analyst or supervisor experienced in the method, and approved by the Laboratory QAO or Laboratory PM. The following are requirements that are generally examined as part of this review:

- Initial calibration criteria were met. Standards in the calibration curve covered the expected concentration ranges of the samples.
- Initial and continuing calibrations met the acceptance criteria defined in the method standard procedure
- Sample results fell within the range of the standard curve
- For GC/MS methods requiring internal standards, retention times and area responses were evaluated against limits established by the daily calibration
- Method blanks were processed with each analytical batch and no detectable levels of contamination were identified
- MS/MSDs were performed at the required frequency and recoveries were within acceptable control limits
- Duplicate analyses were performed at the required frequency and results were within the advisory control limits
- LCS analyses were performed with each analytical batch and the results obtained were within control limits
- For organic compound analyses, surrogate spike recoveries were within control limits
- Compounds identified by GC/MS have been manually rechecked by comparison with the data system library for both target compounds and tentatively identified compounds. Retention times and ratios of fragmentation were verified.
- Calculations have been accurately performed
- Reporting units are correct
- Data for the analysis provide a complete audit trail
- Reported detection limits comply with data quality indicator requirements.

The analyst's supervisor will check a minimum of 10% of the data back to raw data in the secondary review. When required analyses on the samples in a project are complete, entered, and reviewed, a report will be generated.

The report will be forwarded to the Laboratory QAO for review. The report will then be reviewed for the following items (at a minimum):

- QC data will be reviewed to identify whether or not internal specification and contract requirements have been met
- Non-conformance reports, if any, will be reviewed for completion of corrective actions and their impact of results. Non-compliance and corrective action procedures will be documented in the case narrative in the final report.

The report requires the signature of the Laboratory QAO or Laboratory PM. Electronic data are copied onto computer tape, inventoried, and stored off-site in a secure facility, or within locked cabinets on-site. This data archive system is maintained minimally for ten years.

9.2. Data validation

Data validation procedures shall be performed for both field and laboratory operations.

9.2.1. Procedures used to evaluate field data

Procedures to evaluate field data for this project primarily include checking for transcription errors on the part of field crew members and review of field notebooks. This task will be the responsibility of the O'Brien & Gere Field Leader, who will otherwise not participate in making any of the field measurements or in adding notes, data, or other information to the notebook.

9.2.2. Procedures to validate laboratory data

Data validation will be performed by the Environmental Standards' QA Manager in accordance with QA/QC criteria established in this QAPP, as listed in Tables 7A through 7I, and the analytical methods for 100% of the

analytical data. Excursions from QA/QC criteria will be qualified based on guidance provided in the following documents or the most recent USEPA data validation guidelines:

- *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review.* USEPA 540/R-94/012 (USEPA, 1994c)
- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review.* USEPA 540/R-94/013 (USEPA, 1994d)
- *USEPA Region V Standard Operating Procedure For Validation of CLP Organic Data* (USEPA, 1997)
- *USEPA Region V Standard Operating Procedure For Validation of CLP Inorganic Data* (USEPA, 1993b)
- *USEPA Region II Data Validation SOP For SW-846 Method 8290 Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) By High-Resolution Gas Chromatography/ High-Resolution Mass Spectrometry (HRGC/HRMS)* (USEPA, 1994e).

The analytical data from each method and matrix will be reviewed for the QC parameters as presented in the following section. Data validators will recalculate 10% of the laboratory sample calculations using raw data when verifying sample results. In addition, data validators will review 10% of the raw data to verify that compound identification was performed correctly and transcription errors are not present.

Data quality will be evaluated using method or laboratory control limits. Any control limits outside of the acceptable range shall be identified and reported. Sample data will be qualified based on excursions from method or laboratory control limits. Data not within control limits require corrective action by the laboratory. Data validators will check corrective actions and results of reanalysis and document these events in the validation report.

Minor deficiencies in the data generation process noted in the data validation will result in approximation of sample data. Approximation of a data point indicates uncertainty in the reported concentration of the chemical but not its assigned identity. Major deficiencies noted in the data validation will result in the rejection of sample results. Rejected data would be considered unusable for quantitative or qualitative purposes. Data qualifiers may include the following:

U Indicates that the compound was analyzed for, but was not detected. The sample quantitation limit is presented and adjusted for dilution and percent moisture. This qualifier is also used to signify that the detection limit of an analyte was raised as a result of analytes detected in laboratory and/or field blank samples.

J Indicates that the detected sample result should be considered approximate based on excursions from QA/QC criteria. Additionally, for organic analyses this qualifier is used either when estimating a concentration for tentatively identified compounds or when the mass spectra data indicate the presence of a compound that meets identification criteria, but the sample result is less than the compound quantitation limit.

UJ Indicates that the detection limit for the analyte in this sample should be considered approximate based on excursions from QA/QC criteria.

R Indicates that the previously reported detection limit or sample result has been rejected due to a major excursion from QA/QC criteria, for example percent recoveries of less than ten percent. The data should not be used for qualitative or quantitative purposes.

The following method specific QA/QC parameters will be evaluated (at a minimum) during the data validation, where applicable.

Analyses for VOCs and SVOCs (where applicable)

- Holding times, sample preservation, and percent solids
- Dilutions
- GC/MS tuning criteria
- Initial and continuing calibration
- Blank analysis
- Surrogate recovery
- MS/MSD analysis
- Field duplicate analysis
- LCS analysis
- Internal standards performance
- Compound identification and quantitation
- Reported detection limits

- System performance
- Documentation completeness
- Overall assessment.

Analyses for pesticides, PCBs, TPH, and herbicides (where applicable)

- Holding times, sample preservation, and percent solids
- Dilutions
- GC performance
- Analytical sequence
- Initial and continuing calibration
- Blank analysis
- Surrogate recovery
- MS/MSD analysis
- Field duplicate analysis
- LCS and MS blank analysis
- Retention time windows
- Analyte identification, quantitation, and reported detection limits
- Cleanup efficiency verification
- Confirmation analysis
- System performance
- Documentation completeness
- Overall assessment

Analysis for metal, mercury, cyanide, total organic carbon (TOC), fluoride, total phosphorus, and orthophosphateanalyses (where applicable):

- Holding times, sample preservation, and percent solids
- Contract required detection limit (CRDL) standard analysis criteria
- Initial and continuing calibration
- Blank analysis
- ICP interference check sample analysis
- Spike duplicate analysis
- Field duplicate analysis
- LCS analysis
- Laboratory duplicate analysis
- ICP serial dilution analysis
- Furnace atomic absorption analysis
- Verification of instrument parameters
- Instrument detection limits
- Linear ranges
- Analyte quantitation, and reported detection limits
- Documentation completeness
- Overall assessment.

Analysis for PCDDs and PCDFs analyses (where applicable):

- Holding times, sample preservation, and percent solids
- GC/MS tuning criteria
- Column performance check standard analysis
- Initial and continuing calibration
- Blank analysis
- Internal standard criteria
- Recovery standard criteria
- MS/MSD analysis
- Field duplicate analysis
- Compound identification and quantitation
- Confirmation analysis
- System performance
- Documentation completeness
- Overall assessment.

The laboratory will be conducting analyses on samples in accordance with methods listed in Table 3 and the laboratory's SOPs. Data generated by this SSP will be computerized in a format organized to facilitate data review and evaluation. The computerized data set will include the data flags provided by Savannah Labs and Triangle Labs as well as the data validation results.

9.3. Data reporting

Data reporting procedures shall be carried out for field and laboratory operations as indicated below:

9.3.1. Field data reporting

Field data reporting shall be conducted principally through the transmission of field logs containing tabulated results of all measurements made in the field, and documentation of all field calibration activities.

9.3.2. Laboratory data reporting

Data generated through field activities and analyzed by the laboratory shall be reduced by the laboratory, reported to O'Brien & Gere, data validated, then reported to USEPA Region V.

The Laboratory QAO, Laboratory OM, and Laboratory PM must perform a final review of the report summaries and case narratives to determine whether the report meets project requirements. The data packages provided by the laboratory will provide information so that a complete data validation can be performed on the data generated for this project.

The data report forms will be securely bound and pages will be sequentially numbered. The laboratory will provide full data-validatable reports which will include the following information (at a minimum):

- Case narrative report containing a summary of the samples collected, problems with sample receipt, methods employed, QA/QC excursions, and corrective action procedures
- Cross-reference table of sample identifications, laboratory sample identifications, sample matrix, analysis required and performed, date of sample collection, and date of sample receipt
- Case file containing documentation of cooler temperature and preservation checks performed
- Copies of completed chain-of-custody records
- Internal laboratory chain-of-custody records
- Analytical results of environmental samples, field duplicates, equipment blanks, and trip blanks with appropriate reporting limits
- Surrogate recovery results with appropriate laboratory control limits
- Batch-specific QA/QC results for laboratory method blanks, MS/MSDs, and LCSs with appropriate laboratory control limits
- GC/MS tuning data
- Initial and continuing calibration data summarized
- GC/MS internal standard summary forms
- Metals ICP quality control data summarized

- Summary table of MDLs and laboratory reporting limits
- Sample preparation bench sheets, digestion logs, and injection logs
- Appropriate raw instrument outputs for samples, blanks, QA/QC samples, and calibration standards
- Sample data
- Extraction log information
- Corrective action logs
- MDL study.

Tentatively identified compounds will not be required for this project.

Standard preparation logs, use logs, and MDL studies will be made available by the laboratory upon request.

Review and cross-checking procedures will be as described in the laboratory SOPs and will ensure that the raw data and calculation results are properly, completely, and accurately transferred to the laboratory reporting format. In addition to the hardcopy version of the analytical data packages, the laboratory will provide electronic deliverables.

9.4. Data management

Data will be managed in a relational database management system (DBMS). Laboratory analytical data will provided in electronic disk deliverable (EDD) format for direct upload into the DBMS. Associated field data will be entered into the DBMS by hand.

The DBMS will then be used to provide custom queries and reports to support data validation, data analysis, and report preparation.

10. Performance and systems audits

The performance audit is an independent check to evaluate the quality of data being generated. The system audit is an on-site review and evaluation of the laboratories, instrumentation, quality control practices, data validation, and documentation procedures.

At the discretion of the O'Brien & Gere PM, performance and system audits of both field and laboratory activities will be conducted to verify that sampling and analyses are performed in accordance with the procedures established in the FSP and this QAPP. The audits of field and laboratory activities include two independent parts: internal and external audits.

If requested, the internal audits will be performed by the O'Brien & Gere QAO. The external audits will be performed by USEPA Region V.

10.1. Field performance and system audits

10.1.1. Internal field audits

Internal field audit responsibilities. Internal audits of field activities including sampling and field measurements will be conducted by the O'Brien & Gere QAO or her designee.

Internal field audit frequency. These audits will verify that established procedures are being followed. Internal field audits will be conducted at least once at the beginning of the site sample collection activities and annually thereafter.

Internal field audit procedures. The audits will include examination of field sampling records, field instrumentation operating records, sample collection, handling and packaging in compliance with the established procedures, maintenance of QA procedures, chain-of-custody, and other elements of the field program. Follow-up audits will be conducted to correct deficiencies and to verify that QA procedures are maintained

throughout the SSP. The audits will involve review of field measurement records, instrumentation calibration records, and sample documentation. The areas of concern in a field audit include:

- Sampling procedures
- Decontamination of sampling equipment, if applicable
- Chain-of-custody procedures
- SOPs
- Proper documentation in field notebooks.

10.1.2. External field audits

External field audit responsibilities. External field audits may be conducted by USEPA Region V.

External field audit frequency. External field audits may be conducted at any time during the field operations. These audits may or may not be announced and are at the discretion of USEPA Region V.

Overview of the external field audit process. External field audits will be conducted according to the field activity information presented in this QAPP.

10.2. Laboratory performance and system audits

10.2.1. Internal laboratory audits

Internal laboratory audit responsibilities. The internal laboratory audit will be conducted by the O'Brien & Gere QAO.

Internal laboratory audit frequency. The internal laboratory system audits will be conducted on an annual basis while the internal laboratory performance audits will be conducted on a quarterly basis.

Internal laboratory audit procedures. The internal laboratory system audits will include an examination of laboratory documentation on sample receiving, sample log-in, sample storage, chain-of-custody procedures, sample preparation, and analysis, instrumentation operating records, etc. The performance audits will involve reviewing the results for performance evaluation samples sent to the laboratory by regulating agencies. The O'Brien & Gere QAO will evaluate the analytical results to ensure the laboratory maintains acceptable QC performance.

10.2.2. External laboratory audits

External laboratory audit responsibilities. An external audit may be conducted by USEPA Region V.

External laboratory audit frequency. An external laboratory audit may be conducted at least once prior to the initiation of the sampling and analysis activities. These audits may or may not be announced and are at the discretion of USEPA Region V.

Overview of the external laboratory audit process. External laboratory audits will include review of laboratory analytical procedures, laboratory on-site audits, and/or submission of performance evaluation samples to the laboratory for analysis.

The specific parameters to be evaluated (at a minimum) will include:

- Data comparability
- Calibration and quantitation
- QC execution
- Out-of-control events
- SOPs
- Sample management
- Record keeping
- Instrument calibration records
- Other analytical records
- QC records
- Corrective action reports
- Maintenance logs
- Data review
- Limits of detection
- QC limits
- Analytical methods.

11. Preventive maintenance

11.1. Field instrument preventive maintenance

The field equipment for this project includes a pH meter, a conductivity meter, a turbidity meter, thermometers, a PID, a field gas chromatograph, a RAM, an explosimeter, and a magnetometer. Specific preventive maintenance procedures to be followed for field equipment are those recommended by the manufacturer. Field instruments will be checked and calibrated daily before use. Calibration checks will be documented in the field notebooks. Critical spare parts such as tape and batteries will be kept on-site to reduce downtime.

11.2. Laboratory instrument preventive maintenance

As part of their QA/QC programs, routine preventive maintenance programs are conducted by Savannah Labs and by Triangle Labs to minimize the occurrence of instrument failure and other system malfunctions. Savannah Labs and Triangle Labs perform routine scheduled maintenance and coordinate with the vendor for the repair of all instruments. Laboratory instruments are maintained in accordance with manufacturer's specifications and the requirements of the specific method employed. This maintenance is carried out on a regular, scheduled basis, and is documented in the laboratory instrument maintenance logbook for each instrument. Emergency repair or scheduled manufacturer's maintenance is provided under a repair and maintenance contract with factory representatives.

Table 8 provides an example of preventive maintenance for laboratory equipment.

12. Specific routine procedures used to assess data precision, accuracy, and completeness

The procedures to assess the quality of data generated in the laboratory may include, but not be limited to, the following:

- Determination of analytical precision per method
- Determination of analytical accuracy per method
- Determination of analytical completeness.

The quality of data will be determined through evaluation of the appropriate QC measurements according to the specific analytical method used.

Precision and accuracy will be assessed utilizing method limits or control charts, where applicable. Control charts will consist of line graphs which provide a continuous graphic representation of the state of each analytical procedure. The standard deviation of the mean of the QC measurement is calculated, and the upper and lower warning limits are set at plus or minus two standard deviation units. The upper and lower control limits are set at plus or minus three standard deviation units. Acceptable data are realized when results fall between the lower and upper warning limits. If the QC value falls between the control limit and the warning limit, the analysis should be scrutinized as possibly out-of-control.

In general, the accuracy of the methods will be determined by spiking the sample matrix with the analyte and by analyzing reference materials with known concentrations, where applicable. The spiking levels will be selected to reflect the concentration range of interest. Percent recoveries of the spikes and reference materials will be calculated and compared to the established limits. The precision of the methods will be determined by the analysis of MS and laboratory and field duplicate samples. The precision will be evaluated by calculating the RPD between the duplicates. RPD calculations will be compared to the established limits.

The definitions and equations used for the assessment of data quality are discussed below.

12.1. Accuracy assessment

Accuracy is a measure of the nearness of an analytical result, or a set of results, to the true value. It is usually expressed in terms of error, bias, or percent recovery (%R).

Normally, the term accuracy is used synonymously with percent recovery. It describes either the recovery of a synthetic standard of known value, or the recovery of known amount of analyte (spike) added to a sample of known value. The %R or accuracy can be calculated by using:

standards: %R = (observed value/true value) x 100

spikes: %R = (conc. spike + sample conc.) - (sample conc. x 100)/conc. spike

12.2. Precision assessment

Precision refers to the agreement or reproducibility of a set of replicate results among themselves without assumption of any prior information as to the true result. It is usually expressed in terms of the percent difference (%D) or RPD. The %D is calculated by using:

%D = (larger SR - smaller SR x 100)/ smaller SR

where SR is the sample result. The RPD is calculated by using:

RPD = (|OSR - DSR| x 100)/ ((OSR + DSR)/2)

where OSR is the original sample result and DSR is the duplicate sample result.

12.3. Completeness assessment

The completeness is the ratio of the number of valid sample results to the total number of samples analyzed for a specific matrix and/or analysis. It is calculated by using the following equation:

Completeness = number of valid measurements/number of measurements planned x 100.

13. Corrective action

Corrective action is the process of identifying, recommending, approving and implementing measures to counter unacceptable procedures or out-of-control performance which can affect data quality. Corrective action can occur during field activities, laboratory analyses, data validation, and data assessment. Corrective actions proposed and implemented will be documented in the regular quality assurance reports to management. Corrective action should only be implemented after approval by the O'Brien & Gere PM, or the O'Brien & Gere Field Leader. If immediate corrective action is required, approvals secured by telephone from the O'Brien & Gere PM should be documented in an additional memorandum.

For noncompliance problems, a formal corrective action program will be determined and implemented at the time the problem is identified. The person who identifies the problem will be responsible for notifying the O'Brien & Gere PM, who in turn will notify USEPA Region V. Implementation of a corrective action will be confirmed in writing through the same channels. Nonconformance with the established quality control procedures in this QAPP, SSP or FSP will be identified and corrected in accordance with this QAPP. USEPA Region V will issue a nonconformance report for each nonconformance condition.

13.1. Field corrective action

Corrective action in the field can be needed when the sample network is changed (*i.e.*, more or less samples, sampling location changes, and related modifications) or sampling procedures and/or field analytical procedures require modification due to unexpected conditions. Technical staff and project personnel will be responsible for reporting suspected technical or QA nonconformities or suspected deficiencies of any activity or issued document by reporting the situation to the O'Brien & Gere Field Leader. The O'Brien & Gere Field Leader will be responsible for assessing the suspected problems in consultation with the O'Brien & Gere PM and assessing the potential for the situation to impact the quality of the data. If the situation warrants a reportable nonconformance requiring corrective

action, then a nonconformance report will be initiated by the O'Brien & Gere PM.

The O'Brien & Gere PM will be responsible for seeing that corrective action for nonconformance are initiated by:

- Evaluating reported nonconformities
- Controlling additional work on nonconforming items
- Establishing disposition or action to be taken
- Maintaining a log of nonconformities
- Verifying nonconformance reports and corrective actions taken
- Verifying nonconformance reports are included in the final site documentation in project files.

If appropriate, the O'Brien & Gere Field Leader will verify that no additional work that is dependent on the nonconforming activity is performed until the corrective actions are completed. Corrective action for field measurements may include:

- Repeat the measurement to check the error
- Check for all proper adjustments for ambient conditions such as temperature
- Check the batteries
- Re-calibration
- Check the calibration
- Replace the instrument or measurement devices
- Stop work (if necessary).

The O'Brien & Gere Field Leader is responsible for site activities. In this role, the O'Brien & Gere Field Leader at times is required to adjust the site programs to accommodate site-specific needs. When it becomes necessary to modify a program, the responsible person notifies the O'Brien & Gere Field Leader of the anticipated change and implements the necessary changes after obtaining the approval of the O'Brien & Gere Field Leader. The change in the program will be documented on the field change request (FCR) that will be signed by the initiators and the O'Brien & Gere Field Leader. The FCR for each document will be numbered serially as required. The FCR shall be attached to the file copy of the affected document. The O'Brien & Gere Field Leader must approve the change in writing or verbally prior to field implementation, if feasible. If unacceptable, the

action taken during the period of deviation will be evaluated in order to ascertain the significance of any departure from program practices and action taken.

The O'Brien & Gere Field Leader is responsible for the controlling, tracking, and implementing the identified changes. Reports on changes will be distributed to all affected parties, including USEPA Region V.

Corrective action resulting from internal field audits will be implemented immediately if data may be adversely affected due to unapproved or improper use of approved methods. The O'Brien & Gere QAO will identify deficiencies and recommend corrective action to the O'Brien & Gere PM. Implementation of corrective actions will be performed by the O'Brien & Gere Field Leader and the field team. Corrective action will be documented in the quality assurance report to the project management.

Corrective actions will be implemented and documented in the field notebook. No staff member will initiate corrective action without prior communication of findings through the proper channels. If corrective actions are insufficient, work may be stopped by USEPA Region V.

13.2. Laboratory corrective action

Corrective action in the laboratory may occur prior to, during, and after initial analysis. A number of conditions, such as broken sample containers, multiple phases, low or high pH readings, or potentially high concentration samples may be identified during sample log-in or just prior to analysis. Following consultation with laboratory analysts and section leaders, it may be necessary for the Laboratory QAO to approve the implementation of corrective action. Tables 7A through 7I specify conditions during or after analysis that may automatically trigger corrective action or optional procedures. These conditions may include dilution of samples or automatic reinjection or reanalysis of samples.

Corrective actions are required whenever an out-of-control event or potential out-of-control event is noted. The investigative action taken is somewhat dependent on the analysis and the event.

Laboratory personnel are alerted that corrective actions may be necessary if:

- QC data are outside the acceptable windows for precision and accuracy

- Blanks contain target analytes above acceptable levels
- Undesirable trends are detected in spike recoveries or RPD between duplicates
- There are unusual changes in the detection limits
- Deficiencies are detected by the QA Department during internal or external audits or from the results of performance evaluation samples
- Inquiries concerning data quality are received.

Corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors, checks the instrument calibration, spike and calibration mixes, instrument sensitivity, etc. If the problem persists or cannot be identified, the matter is referred to the Laboratory OM, Laboratory PM, and Laboratory QAO for further investigation. Once resolved, full documentation of the corrective action procedure is filed with the QA department.

Tables 7A through 7I describe the quality control requirements and the corrective actions associated with those requirements for each type of analysis required for this SSP.

These corrective actions are performed prior to release of the data from the laboratory. The corrective actions will be documented in both the laboratory corrective action log and the case narrative. If corrective action does not rectify the situation, the laboratory will contact the O'Brien & Gere QAO.

13.3. Corrective action during data validation and data assessment

The O'Brien & Gere QAO and Laboratory QAO may identify the need for corrective action during either the data validation or data assessment. Potential types of corrective action may include resampling by the field team or reinjection or reanalysis of samples by the laboratory.

These actions are dependent upon the ability to mobilize the field team or whether the data to be collected are necessary to meet the required quality assurance objectives. When the O'Brien & Gere QAO or Laboratory QAO

identifies a corrective action situation, it is the O'Brien & Gere PM who will be responsible for approving the implementation of corrective action, including resampling, during data assessment. Corrective actions of this type will be documented by the O'Brien & Gere QAO and the Laboratory QAO.

14. Quality assurance reports to management

The deliverables associated with the tasks identified in the SSP and monthly progress reports will contain a separate QA section in which data quality information collected during the task is summarized. Those reports will be the responsibility of the O'Brien & Gere PM and will include the O'Brien & Gere QAO and Laboratory QAO report on the accuracy, precision, and completeness of the data as well as the results of the performance and system audits, and any corrective action needed or taken during the project.

14.1. Contents of project QA reports

The QA reports will contain on a routine basis results of field and laboratory audits, information generated during the past month reflecting the achievement of specific data quality objectives, and a summary of corrective action that was implemented and its immediate results on the project. The status of the project with respect to the project schedule will be established. Whenever necessary, changes in key personnel and anticipated problems in the field or the laboratory for the coming month that could bear on data quality, along with proposed solutions, will be reported. Detailed references to QAPP modifications will also be highlighted. QA reports will be prepared in written format by the O'Brien & Gere PM. In the event of an emergency, or in case it is essential to implement corrective action immediately, QA reports can be made by telephone to the appropriate individuals, as identified in the project organization section of this QAPP. However, these events and their resolution will be addressed thoroughly in the next issue of the monthly QA report.

14.2. Frequency of QA reports

The QA reports will be prepared on a monthly basis. The reports will continue without interruption until the project has been completed.

14.3. Individuals receiving/reviewing QA reports

Individuals identified in Chapter 2 of this QAPP will receive copies of the monthly QA reports.

References

American Public Health Association (APHA), American Water Works Association (AWWA), Water Pollution Control Federation (WPCF), 1992. *Standard Methods for the Examination of Water and Wastewater,* 18th Edition, Washington, D.C.

Ecology and Environment, Inc. 1998. *Volume 1 Sauget Area 1 Data Tables/Maps.* USEPA Alternative Remedial Contracting Strategy (ARCS) Contract No. 68-W8-0086. Work Assignment No. 47-5N60.

O'Brien & Gere Engineers, Inc. 1999. *Field Sampling Plan, Sauget Area 1 Support Sampling Project, Sauget and Cahokia, Illinois Volume 2.*

O'Brien & Gere Engineers, Inc. 1999. *Health and Safety Plan, Sauget Area 1 Support Sampling Project, Sauget and Cahokia, Illinois, Volume 2.*

Solutia Inc. 1999. *Sauget Area 1, Sauget and Cahokia, Illinois, Support Sampling Plan.*

U.S. Environmental Protection Agency (USEPA). 1980. *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80.*

U.S. Environmental Protection Agency (USEPA). 1983. *Methods for Chemical Analysis of Water and Wastes*, Cincinnati, Ohio.

U.S. Environmental Protection Agency (USEPA). 1988. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA/600/4-89/017, June 1988, Research Triangle Park, NC.

U.S. Environmental Protection Agency (USEPA). 1993. *Method for the Determination of Inorganic Substances in Environmental Chemical Analysis for Water and Wastes*, EPA-600/4-79-020, Cincinnati, Ohio.

U.S. Environmental Protection Agency (USEPA). 1993b. *Region V Standard Operating Procedure For Validation of CLP Inorganic Data.*

U.S. Environmental Protection Agency (USEPA). 1993c. *Data Quality Objectives Process For Superfund, Interim Final Guidance.*

U.S. Environmental Protection Agency (USEPA). 1994a. *Guidance for the Data Quality Objectives Process* USEPA QA/G-4.

U.S. Environmental Protection Agency (USEPA). 1994b. *Requirements for Quality Assurance Project Plans for Environmental Data Operation USEPA* QA/R-5.

U.S. Environmental Protection Agency (USEPA). 1994c. *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, USEPA 540/R-94/012, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 1994d. *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, USEPA 540/R-94/013, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 1994e. *Region II Data Validation SOP For SW-846 Method 8290 Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) By High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS).*

U.S. Environmental Protection Agency (USEPA). 1996. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition. Washington D.C.*

U.S. Environmental Protection Agency (USEPA). 1996. *Region V Superfund Model Quality Assurance Project Plan*, Revision 1.

U.S. Environmental Protection Agency (USEPA). 1997. *Region V Standard Operating Procedure For Validation of CLP Organic Data.*

U.S. Environmental Protection Agency (USEPA). 1999. *Final Administrative Order by Consent, Sauget Area 1 Site, Sauget and Cahokia, Illinois.*

TABLES

Table 1. *Sampling efforts, objectives, analyses, data uses, and analytical level.*

Sampling effort	Objective	Types of analysis	Data uses	Analytical level
Soil gas survey	Quantify VOCs at sites G, H, I, L, and N.	VOCs	Identify extent of VOC containing soils in the fill areas	Screening data
Waste sampling	Quantify VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, zinc, copper, dioxin, dibenzofuran at sites G, H, I, L, and N.	Ignitability, corrosivity, reactivity, TCLP-VOCs, TCLP-SVOCs, TCLP-pesticides, TCLP-PCBs, TCLP-herbicides, TCLP-metals, TCLP-mercury, TCLP-cyanide, TCLP-dioxin and dibenzofuran	Identify nature of waste materials	Definitive data
Soil sampling	Quantify VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, dibenzofuran at transects to Dead Creek and in developed areas.	VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, dibenzofuran, hardness, pH	Identify and quantify constituents in soil adjacent to Dead Creek	Definitive data
Ground water sampling	Quantify VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, dibenzofuran at sites G, H, I, L, and N.	VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxin, dibenzofuran	Identify and quantify constituents in existing monitoring wells, down gradient alluvial aquifer, bedrock aquifer, and domestic wells	Definitive data
Surface water sampling	Quantify VOCs, SVOCs, metals, mercury, cyanide, fluoride, total phosphorus, orthophosphate, PCBs, pesticides, herbicides, dioxin, dibenzofuran, TSS, TDS, and hardness in surface water of Dead Creek.	VOCs, SVOCs, metals, mercury, cyanide, fluoride, total phosphorus, orthophosphate, PCBs, pesticides, herbicides, dioxin, dibenzofuran, TSS, TDS, hardness, pH	Identify extent of downstream migration	Definitive data
Sediment sampling	Quantify VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, zinc, copper, dioxin, dibenzofuran, TPH, TOC in Dead Creek and borrow pit lake sediments	VOCs, SVOCs, pesticides, PCBs, herbicides, metals, mercury, cyanide, zinc, copper, dioxin, dibenzofuran, TPH, TOC, solids, hardness, pH, grain size	Calculate sample volume. Identify extent of downstream migration	Definitive data

Table 1. *Sampling efforts, objectives, analyses, data uses, and analytical level.*

Sampling effort	Objective	Types of analysis	Data uses	Analytical level
Air sampling	Quantify VOCs, SVOCs, PCBs, dioxin, and metals in ambient air	VOCs, SVOCs, PCBs, dioxin, metals	Identify and quantify constituents in air upwind and downwind of sites G, H, I, and L	Definitive data
Pilot test sampling	Collect waste, sediment, and leachate of samples for treatability study	By technology contractors	Treatability studies, technology evaluations	Screening data
Ground water sampling and surface water sampling	Quantify parameters in wells, aquifers, and Dead Creek	Specific conductance, turbidity, pH, temperature	Evaluate ground and surface water data	Definitive data

Notes:
VOCs indicate volatile organic compounds.
SVOCs indicate semivolatile organic compounds.
PCBs indicate polychlorinated biphenyls.
TPH indicates total petroleum hydrocarbons.
TOC indicates total organic carbon.
TCLP indicates toxicity characteristic leaching procedure, which is performed to prepare a leachate, which is analyzed for VOCs, SVOC, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxins and dibenzofurans.
Source: O'Brien & Gere Engineers, Inc.

Table 2. *Analytical methods for parameters*

Sample type	Parameter	Analytical method	Reference
Ground water, surface water	VOCs	USEPA Method 5030B/8260B	1
Soil, sediment, waste	VOCs	USEPA Method 5035/8260B	1
Air	VOCs	USEPA Method TO-1	2
Ground water, surface water	SVOCs	USEPA Method 3520C/8270C	1
Soil, sediment, waste	SVOCs	USEPA Method 3550B/8270C	1
Air	SVOCs	USEPA Method TO-13	2
Ground water, surface water	Pesticides	USEPA Method 3520C/8081A	1
Soil, sediment, waste	Pesticides	USEPA Method 3550B/8081A	1
Ground water, surface water	PCBs	USEPA Method 680	7
Soil, sediment, waste	PCBs	USEPA Method 680	7
Air	Pesticides/PCBs	USEPA Method TO-4	2
Ground water, surface water	Herbicides	USEPA Method 3520C/8151A	1
Soil, sediment, waste	Herbicides	USEPA Method 3550B/8151A	1
Ground water, surface water	Dioxin, Dibenzofuran	USEPA Method 8290	1
Soil, sediment	Dioxin, Dibenzofuran	USEPA Method 8290	1
Ground water	Dioxin, Dibenzofuran	USEPA Method 8280A	1
Soil, waste	Dioxin, Dibenzofuran	USEPA Method 8280A	1
Air	Dioxin, Dibenzofuran	USEPA Method TO-9	2
Ground water, surface water	Metals	USEPA Method 3015/6010B USEPA Method 7470A (Mercury)	1
Air	Metals	USEPA Method 6010B	1
Soil, sediment, waste	Metals	USEPA Method 3051/6010B USEPA Method 7471A (Mercury)	1
Sediment	Zinc, Copper	USEPA Method 7951 (Zinc) USEPA Method 7211 (Copper)	1
Ground water, surface water	Cyanide	USEPA Method 9010B/9012A	1
Soil, sediment, waste	Cyanide	USEPA Method 9010B/9012A	1
Sediment	TOC	USEPA Method 9060	1
Sediment	TPH	USEPA Method 8015B	1
Surface water	Fluoride	USEPA Method 300.0	5
Surface water	Total Phosphorus	USEPA Method 365.4	3

Table 2. *Analytical methods for parameters*

Sample type	Parameter	Analytical method	Reference
Surface water	Orthophosphate	USEPA Method 300.0	5
Waste	Ignitability	USEPA Method 1010/1020A	1
	Corrosivity	USEPA Method 9045	1
	Reactivity	USEPA Method 9014/9012/9030	1
Waste	TCLP preparation	USEPA Method 1311	1
Surface water	TSS	USEPA Method 160.2	3
	TDS	USEPA Method 160.1	3
	Hardness	USEPA Method 130.1/130.2	3
Soil, sediment, waste	pH	USEPA Method 9040/9045	3
Soil, sediment, waste	Percent solids	SM 2540G	4
Ground water	Specific conductance	E120.1	3
Ground water	pH	E150.1	3
Ground water	temperature	E170.1	3
Ground water	turbidity	E180.1	3
Soil gas	Total VOCs	USEPA Method 3810 Modified	1, 6

Notes:
*USEPA Method 8290 will be performed for ground water, surface water, soil, and sediment samples that are expected to contain lower concentrations of dioxins and dibenzofurans. USEPA Method 8280A will be performed for ground water, soil, and waste samples that are expected to contain higher concentrations of dioxins and dibenzofurans
VOCs indicate volatile organic compounds
SVOCs indicate semivolatile organic compounds
PCBs indicate polychlorinated biphenyls.
TPH indicates total petroleum hydrocarbons.
TSS indicates total suspended solids.
TDS indicates total dissolved solids.
TOC indicates total organic carbon.
TCLP indicates toxicity characteristic leaching procedure, which is performed to prepare a leachate, which is analyzed for VOCs, SVOC, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxins and dibenzofurans.

1 USEPA. 1996a. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846*, 3rd Edition. Washington D.C.
2 USEPA. 1988. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, Research Triangle Park, NC.
3 USEPA. 1983. *Methods For Chemical Analysis of Water and Wastes*, Cincinnati, Ohio.
4 *Standard Methods for the Examination of Water and Wastewater*, 18th Edition, Washington, D.C., APHA, AWWA, WPCF, 1992.
5 USEPA. 1993. *Method for the Determination of Inorganic Substances in Environmental Chemical Analysis for Water and Wastes*, EPA-600/4-79-020. Cincinnati, Ohio.
6 Static headspace gas chromatography, attached in Appendix C.
7 USEPA. 1985. *Determination of Pesticides and PCBs in Water and Soil/Sediment by Gas Chromatography/Mass Spectrometry, Physical and Chemical Methods Branch*, Environmental Monitoring and Support Laboratory, Office of Research and Development, Cincinnati, Ohio.

Source: O'Brien & Gere Engineers, Inc.

Table 3. *Field sampling summary for chemical analyses.*

Parameter (critical method)	Matrix	Sample containers and volumes	Preservation	Holding times	Number of Investigative Samples	QC sample frequency			
						Field duplicate	Trip blank	MS/MSD /Spike Duplicate*	Equip. blank**
VOCs (USEPA Method 8260B)[1]	Ground water/ surface water	3-40 milliliter glass vials with Teflon® lined septum caps	4°C HCL to pH<2 FC	14 days from collection	175/20	one per 10 samples or one per matrix (for less than 10 samples)	1 ea. per cooler with VOC samples	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
VOCs (USEPA Method 8260B)[1]	Soil/sediment/waste	3- Encore sampler™ (or in accordance with USEPA Method 5035)	4°C	Transferred to soil container or analyzed 48 hours from collection For TCLP-VOCs, 14 days from collection to TCLP extract generation, 14 days from TCLP extract generation to analysis	133/20/24	one per 10 samples or one per matrix (for less than 10 samples)	1 ea. per cooler with VOC samples	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
VOCs (USEPA Method TO1)[2]	Air	Sample cartridge/ filter as described in Method TO1	4°C	7 days from collection to analysis	13	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
SVOCs (USEPA Method 8270C)[1]	Ground water/ surface water	2-one liter amber glass container with Teflon® lined screw caps	4°C FC	7 days from collection to extraction; 40 days from extraction to analysis	145/20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
SVOCs (USEPA Method 8270C)[1]	Soil/sediment/waste	250 milliliter wide mouth glass container with Teflon® lined lid	4°C	14 days from collection to extraction; 40 days from extraction to analysis For TCLP-SVOCs, 14 days from collection to TCLP extract generation, 7 days from TCLP extract generation to extraction, 40 days from extraction to analysis	133/20/24	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.

Table 3. *Field sampling summary for chemical analyses.*

Parameter (critical method)	Matrix	Sample containers and volumes	Preservation	Holding times	Number of investigative Samples	QC sample frequency			
						Field duplicate	Trip blank	MS/MSD /Spike Duplicate*	Equip. blank**
SVOCs (USEPA Method TO13)[2]	Air	Sample cartridge/ filter as described in Method TO13	4°C	7 days from collection to analysis	13	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Pesticides, Herbicides (USEPA Methods 8081A, 8151A)[1]	Ground water/ surface water	4-one liter amber glass container with Teflon® lined screw caps	4°C	7 days from collection to extraction; 40 days from extraction to analysis	145/20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Pesticides, Herbicides (USEPA Methods 8081A, 8151A)[1]	Soil/sediment/waste	250 milliliter wide mouth glass container with Teflon® lined lid	4°C	14 days from collection to extraction; 40 days from extraction to analysis 14 days from collection to extraction; 40 days from extraction to analysis For TCLP, 14 days from collection to TCLP extract generation, 14 days from TCLP extract generation to extraction, 40 days from extraction to analysis	133/125/24	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
PCBs (USEPA Method 680)[4]	Ground water/ surface water	2-one liter amber glass container with Teflon® lined screw caps	4°C	7 days from collection to extraction; 40 days from extraction to analysis	145/20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
PCBs (USEPA Method 680)[4]	Soil/sediment/waste	500 milliliter wide mouth glass container with Teflon® lined lid	4°C	14 days from collection to extraction; 40 days from extraction to analysis 14 days from collection to extraction; 40 days from extraction to analysis	133/125/24	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.

Table 3. *Field sampling summary for chemical analyses.*

Parameter (critical method)	Matrix	Sample containers and volumes	Preservation	Holding times	Number of investigative Samples	QC sample frequency			
						Field duplicate	Trip blank	MS/MSD /Spike Duplicate*	Equip. blank**
PCBs (USEPA Method TO4)[2]	Air	Sample cartridge/ filter as described in Method TO4	4°C	7 days from collection to analysis	13	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
***Dioxin, Dibenzofuran (USEPA Method 8290[1])	Ground water/ surface water	2-one liter amber glass container with Teflon® lined screw caps	4°C FC	30 days from collection to extraction; 45 days from extraction to analysis	71/20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
***Dioxin, Dibenzofuran (USEPA Method 8290[1])	Sediment	100 grams in 4 oz. amber glass jar with Teflon® lined lid	4°C	30 days from collection to extraction; 45 days from extraction to analysis	20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
***Dioxin, Dibenzofuran (USEPA Method 8280A[1])	Soil/sediment/waste	100 grams in 4 oz. amber glass jar with Teflon® lined lid	4°C	30 days from collection to extraction; 45 days from extraction to analysis	81/20/24	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Dioxin, Dibenzofuran (USEPA Method TO9)[2]	Air	Sample cartridge/ filter as described in Method TO9	4°C	7 days from collection to analysis	13	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.

Table 3. *Field sampling summary for chemical analyses.*

Parameter (critical method)	Matrix	Sample containers and volumes	Preservation	Holding times	Number of Investigative Samples	QC sample frequency			
						Field duplicate	Trip blank	MS/MSD /Spike Duplicate*	Equip. blank**
Metals, Mercury (USEPA Methods 6010B, 7470A)[1]	Ground water/ surface water	1-250 or 500 milliliter polyethylene or fluorocarbon (TFE or PFA) container	HNO_3 to pH<2, 4°C	180 days from collection 28 days from collection for mercury	145/20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Metals, Mercury (USEPA Methods 6010B, 7471A)[1]	Soil/sediment/waste	4 ounce wide mouth polyethylene or fluorocarbon (TFE or PFA) container	4°C	180 days from collection 28 days from collection for mercury For TCLP, 180 days from collection to TCLP extract generation, (28 days for mercury), 180 days (28 days for mercury) from extraction to analysis	133/20/24	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Zinc, Copper (USEPA Methods 7951, 7211)[1]	Sediment	4 ounce wide mouth polyethylene or fluorocarbon (TFE or PFA) container	4°C	180 days from collection	105	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Cyanide (USEPA Method 9010B/9012A)[1]	Ground water/ surface water	1-250 or 500 milliliter plastic bottle	NaOH to pH>12, 4°C OA	14 days from collection	145/20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Cyanide (USEPA Method (9010B/9012A)[1]	Soil/sediment/waste	4 ounce wide mouth glass container with Teflon® lined lid	4°C	14 days from collection	133/20/24	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.

Table 3. *Field sampling summary for chemical analyses.*

Parameter (critical method)	Matrix	Sample containers and volumes	Preservation	Holding times	Number of Investigative Samples	QC sample frequency			
						Field duplicate	Trip blank	MS/MSD /Spike Duplicate*	Equip. blank**
TOC (USEPA Method 9060[1])	Sediment	4 ounce wide mouth glass container with Teflon® lined lid	4°C	28 days from collection	125	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
TPH (USEPA Method 8015B[1])	Sediment	4 ounce wide mouth glass container with Teflon® lined lid	4°C	14 days from collection to extraction; 40 days from extraction to analysis	105	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Fluoride (USEPA Method 300.0[5])	Surface water	1-250 or 500 milliliter plastic bottle	4°C	28 days from collection to analysis	20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Total Phosphorus (USEPA Method 365.4[3])	Surface water	1-liter plastic bottle	2 milliliters of H_2SO_4 for each liter, 4°C	28 days from collection to analysis	20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Orthophosphate (USEPA Method 300.0[5])	Surface water	1-250 or 500 milliliter plastic bottle	4°C	48 hours from collection to analysis	20	one per 10 samples or one per matrix (for less than 10 samples)	NA	one per 20 samples or one per matrix (for less than 20 samples)	one per 10 samples as required.
Hardness (USEPA Method 130.1/130.2[3])	Surface water	1-250 ml polyethylene or fluorocarbon container	4°C, HNO_3 to pH <2	6 months from collection	20	one per 10 samples or one per matrix (for less than 10 samples)	NA	NA	one per 10 samples as required.

Table 3. *Field sampling summary for chemical analyses.*

Parameter (critical method)	Matrix	Sample containers and volumes	Preservation	Holding times	Number of Investigative Samples	QC sample frequency			
						Field duplicate	Trip blank	MS/MSD /Spike Duplicate*	Equip. blank**
Total suspended solids (USEPA Method 160.2[3])	Surface water	1-250 or 500 milliliter plastic bottle	4°C	7 days	20	NA	NA	NA	one per 10 samples as required.
Total dissolved solids (USEPA Method 160.1[3])	Surface water	1-250 or 500 milliliter plastic bottle	4°C	7 days	20	NA	NA	NA	one per 10 samples as required.
pH (USEPA Method 150.1/150.2[3])	Surface water	100 ml plastic container	4°C	As soon as possible	20	one per 10 samples or one per matrix (for less than 10 samples)	NA	NA	one per 10 samples as required.
Ignitability (USEPA Method 1010/1020A[1])	Waste	100 ml plastic container	4°C	As soon as possible	44	NA	NA	NA	NA
Corrosivity (USEPA Method 9045[1])	Waste	100 ml plastic container	4°C	As soon as possible	44	NA	NA	NA	NA
Reactivity (USEPA Method 9014/9012/9030[1])	Waste	100 ml plastic container	4°C	As soon as possible	44	NA	NA	NA	NA

Table 3. *Field sampling summary for chemical analyses.*

Parameter (critical method)	Matrix	Sample containers and volumes	Preservation	Holding times	Number of investigative Samples	QC sample frequency			
						Field duplicate	Trip blank	MS/MSD /Spike Duplicate*	Equip. blank**

NOTES:

*MS/MSD indicates matrix spike/matrix spike duplicate sample for organic analyses. Spike duplicate is performed for inorganic analyses.

** Field/equipment blank is required at a frequency of one per 10 samples or one per day if less than ten samples are collected. Equipment blank is not required if disposable equipment is used.

***For dioxin and dibenzofuran sample collection, QC samples, including MS/MSD and field duplicates must be clearly noted on the chain-of-custody.

1 - USEPA. 1996a. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846,* 3rd Edition. Washington D.C.

2 - USEPA. 1988. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air,* EPA/600/4-89/017, Research Triangle Park, NC.

3 - USEPA. 1983. *Methods for Chemical Analysis of Water and Wastes,* Cincinnati, Ohio.

4 - USEPA. 1985. *Determination of Pesticides and PCBs in Water and Soil/Sediment by Gas Chromatography/Mass Spectrometry, Physical and Chemical Methods Branch,* Environmental Monitoring and Support Laboratory, Office of Research and Development, Cincinnati, Ohio.

5 - USEPA. 1993. *Method for the Determination of Inorganic Substances in Environmental Chemical Analysis for Water and Wastes,* EPA-600/4-79-020. Cincinnati, Ohio.

Equip. indicates equipment.

FC indicates that if free chlorine is present in samples, it must be removed by the appropriate addition of $Na_2S_2O_3$.

OA indicates that if oxidizing agents are present, add 5 ml 0.1N $NaAsO_2$ per liter and 0.6g of ascorbic acid per liter.

VOCs indicates volatile organic compounds.

SVOCs indicate semivolatile organic compounds.

PCBs indicate polychlorinated biphenyls.

TPH indicates total petroleum hydrocarbons.

TOC indicates total organic carbon.

TCLP indicates toxicity characteristic leaching procedure, which is performed to prepare a leachate, which is analyzed for VOCs, SVOC, pesticides, PCBs, herbicides, metals, mercury, cyanide, dioxins and dibenzofurans.

NA indicates not applicable.

TBD indicates that the number of environmental samples will be determined at a later date.

Grain size, which is a physical analysis, is not included in the table.

Pilot test sampling will be performed by the pilot test vendor.

Source: O'Brien & Gere Engineers, Inc.

Table 4A. *Laboratory Standard Operating Procedures (SOPs) and Quality Assurance Manual (QAM) for Savannah Laboratories & Environmental Services, Inc. utilized for monitoring activities.*

Laboratory SOP title	SOP number	SOP date
Chlorinated Herbicides (Methods 615 and 8151A)	SG65	1/14/99
Petroleum Products, DRO, and Total Hydrocarbons by gas chromatography modified 8015B extractables	SG70	1/16/99
Total Cyanide and Cyanide Amenable to Chlorination by Manual Distillation	GE46-M	11/25/97
Mercury: Varian Spectra AA 20	ME26	5/1/98
Mercury Analysis: Leeman PS200	ME28	12/19/97
Mercury Preparation: Leeman AP200	ME29	1/20/98
Digestion Procedures for ICP Total Metals and Total Recoverable Metals in Liquid Samples	ME50	4/6/98
Digestion Procedures for ICP Total Metals in Soils, Sediments, Wastes and Oils	ME51	7/6/98
Digestion Procedures for Graphite Furnace Atomic Absorption Total Metals and Total Recoverable Metals in Liquid Samples	ME60	4/8/98
Digestion Procedures for Graphite Furnace Atomic Absorption Total Metals in Soils, Sediments, Wastes and Oils	ME61	7/6/98
Elements by ICP (Methods 200.7 and 6010B)	ME70	6/19/98
Receipt. Log Number Assignment and Distribution of Field Samples	CU01	4/29/98
Internal Chain of Custody	CU02	7/10/98
Preparation of Sampling Kits	CU15	6/24/98
Continuous Liquid-Liquid Extraction	EX30	8/27/98
Ultrasonic Extraction	EX40	2/20/98
Extraction of Chlorinated Herbicides in Water, Soils and Wastes	EX45	11/25/97
Zymark Extract Concentration Procedure	EX50	8/8/97
Preparation of SVOA Surrogate and Matrix Spiking Solutions	EX70	11/25/97
Total Organic Carbon in Soil: Walkley-Black Method	BA05	8/29/97
Total Organic Carbon-Shimadzu TOC Analyzer	BA09	5/1/98
Total Organic Carbon: Dohrmann DC-80 Method	BA11	5/1/98
pH Electrometric Measurement of Water, Soil, and Waste	BA70	3/12/97
Total and Amenable Cyanide: Autoanalyzer Procedure	GE40	8/25/98
Total Cyanide: Autodistillation Procedure	GE41	5/1/98
Midi Distillation of Water and Soils for the Determination of Cyanide	GE43	3/6/98
Organochlorine Pesticides and PCBs	SG45	7/17/98
Graphite Furnace AA	ME75	3/26/98
Semivolatile Compounds by GC/MS	SM05	4/13/98
Modified 8015 Purge and Trap for Petroleum identification	VG15	9/4/98

Table 4A. *Laboratory Standard Operating Procedures (SOPs) and Quality Assurance Manual (QAM) for Savannah Laboratories & Environmental Services, Inc. utilized for monitoring activities.*

Laboratory SOP title	**SOP number**	**SOP date**
Volatile Compounds by GC/MS (8260)	VM20	10/28/98

QAM title and sections	**QAM date**
Savannah Laboratories & Environmental Services, Inc. Corporate Quality Assurance Plan	1/9/99
QAM Sections:	
1.0 Title and Signature Page	
2.0 Table of Contents	
3.0 Statement of Policy	
4.0 Project Organization and Responsibility	
5.0 Quality Assurance Objectives (Precision, Accuracy and MDLs)	
6.0 Sampling Procedures	
7.0 Sample Custody	
8.0 Analytical Procedures	
9.0 Calibration Procedures and Frequency	
10.0 Preventive Maintenance	
11.0 Quality Control Checks and Routines to Access Precision and Accuracy Calculations of Method Detection Limits	
12.0 Data Reduction, Review and Reporting	
13.0 Corrective Action	
14.0 Performance and System Audits	
15.0 Quality Assurance Reports	
16.0 Training & Qualifications	
17.0 Documentation and Records	
18.0 Procurement	
19.0 Quality Improvement/Management Assessment	
20.0 Table of Target Analytes	

Table 4B. *Laboratory Standard Operating Procedures (SOPs) and Quality Assurance Manual (QAM) for Triangle Laboratories, Inc. utilized for monitoring activities.*

Laboratory SOP title	SOP number	SOP date
PCDDs and PCDFs by GC/MS Method 8280A	DHR187	6/8/98
PCDDs and PCDFs by GC/MS Method 8290	DHR182	3/25/98
Extraction of PCDD/PCDF From Water for Methods 1613, 8290 and 551	DSP161	10/23/98
Extraction of PCDD//PCDF From Solids (not tissue) - 8290	DSP105	7/31/98
Extraction of PCDD/PCDF From Water for Methods 8280A	DSP224	11/10/98
Extraction of PCDD//PCDF From Solids (not tissue) -8280A	DSP289	2/12/99

QAM title and sections	QAM date
Quality Assurance Triangle Laboratories, Inc. QAM Sections: 1.0 Introduction 2.0 Authorization 3.0 Management of the Quality Assurance Manual 4.0 Objectives and Policies 5.0 Laboratory Description 6.0 Organization and Personnel 7.0 Analytical Services 8.0 Laboratory Materials - Purchasing and Handling 9.0 Analytical Standards 10.0 Sample Receipt, Handling and Preparation 11.0 Instrumentation and Equipment 12.0 Data Handling and Software Management 13.0 Documentation of Quality Assurance 14.0 Quality Assurance 15.0 Quality Control	11/14/97

Table 5A. *USEPA methods 6010B, 7211, 7951, 7470, 9010B, 9060, 8015B, 130.1, 300.0, and 365.4 detection limits.*

Analyte	Water (mg/L)					
	PQLs	MDLs	Surface water DQL (m)	Ground water DQL (a)	Basis	Selected DQL(p)
Aluminum	0.200	0.027	NA	37	C(n,c)	37
Antimony	0.020	0.005	4.3	0.006	B	0.006
Arsenic	0.010	0.0032	0.00014	0.001	A	0.00014
Barium	0.010	0.0012	NA	2	B	2
Beryllium	0.004	0.00054	NA	0.004	A	0.004
Cadmium	0.005	0.00071	NA	0.005	B	0.005
Calcium	0.500	0.044	NA	NA	F	NA
Chromium	0.010	0.0017	NA	0.1	B	0.1
Cobalt	0.010	0.0014	NA	1	B	1
Copper	0.020	0.0009	NA	0.65	B	0.65
Copper (Method 7211)	0.020	0.00067	NA	0.65	B	0.65
Iron	0.050	0.018	NA	5	B	5
Lead	0.005	0.0015	NA	0.0075	B	0.0075
Magnesium	0.500	0.110	NA	NA	F	NA
Manganese	0.010	0.0014	0.1	0.15	B	0.1
Mercury (Method 7470)	0.0002	0.000072	0.000051	0.002	B	0.000051
Nickel	0.040	0.0047	4.6	0.1	B	0.1
Potassium	1.0	0.190	NA	NA	F	NA
Selenium	0.010	0.0042	11	0.05	B	0.005
Silver	0.010	0.0019	NA	0.05	B	0.05
Sodium	0.500	0.310	NA	NA	F	NA
Thallium	0.010	0.0049	0.0063	0.002	B	0.002
Vanadium	0.010	0.0022	NA	0.049	B	0.049
Zinc	0.020	0.0059	69	5	B	5
Zinc (Method 7951)	0.020	*	69	5	B	5
Cyanide (Method 9010B)	0.010	---	220	0.2	B	0.2
TOC (Method 9060)	0.001	0.00053	NA	NA	E	NA
Hardness (Method 130.1)	0.0033	---	NA	NA	E	NA
TPH (Method 8015B)	0.300	0.100	NA	NA	E	NA
Residue, dissolved	0.005	N/A	NA	NA	E	NA
Residue, suspended	0.005	N/A	NA	NA	E	NA
Fluoride	0.100	0.01	NA	4	B	4
Total phosphorus	0.100	0.34	NA	0.73(n, c)	C	0.73

Table 5A. *USEPA methods 6010B, 7211, 7951, 7470, 9010B, 9060, 8015B, 130.1, 300.0, and 365.4 detection limits.*

Analyte	Water (mg/L)					
	PQLs	MDLs	Surface water DQL (m)	Ground water DQL (a)	Basis	Selected DQL(p)
Orthophosphate	0.05	0.009		NA	E	NA

Notes:
DQL indicates data quality limit.
PQL indicates laboratory practical quantitation limits.
MDL indicates laboratory detection limits.
--- indicates detection limit not provided.
N/A indicates not applicable.
MDL studies were performed in 1999.
*Indicates the MDL study will be performed prior to sample analysis.
(a) - The following hierarchy was used to determine the appropriate DQL:
1. ADL value from Appendix A Table H from the Illinois Tiered Approach to Corrective Action (TACO) program.
2. For constituents not on Table H, the value for Classl GW from Appendix B Table E was used.
3. For constituents with no TACO values, the Region IX PRG for tap water was used.
4. For remaining constituents, a default value equivalent to the lowest DQL for that ty7pe of constituent was used.
(c) - Value for dis-1,2-Dichloroethylene.
(m) - Surface water values were obtained from Federal Register, Vol. 63, No. 237. Value for Human Health Consumption of Organisms.
(n) - Due to structural similarities, the value for alpha-BHC was used.
(p) - Selected DQL is the lower of the surface water and ground water DQLs.
A - IEPA, 1998, Appendix A, Table H, Acceptable Detection Limit (ADL) Value.
B - IEPA, 1998, Appendix B, Table E, Value for Class I Groundwater.
E - No toxicity information is available for this constituent; therefore, DQL was not developed.
F - No value is available as this constituent is an essential nutrient.
NA - Not available.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5B. *USEPA methods 6010B, 7211, 7951, 7471, 9010B, 9060, 8015B, 300.0, and 365.4 detection limits.*

Analyte	Soil (mg/kg)			
	PQLs	MDLs	DQL (g)	Basis
Aluminum	20	5.8	7.5E+04	E
Antimony	2	0.5	5	H
Arsenic	1	0.45	0.04	D
Barium	1	0.16	260	H
Beryllium	0.4	0.057	1	D
Cadmium	0.5	0.087	1	H
Calcium	50	20	NA	J
Chromium	1	0.17	28(c)	H
Cobalt	1	0.19	4,700	D
Copper	2	0.72	330	H
Copper (Method 7211)	2	0.042	330	H
Iron	5	4.5	22,000	E
Lead	0.5	0.42	400	D
Magnesium	50	6.8	NA	J
Manganese	1	0.21	411	D
Mercury (Method 7471)	0.02	0.0028	0.1	H
Nickel	4	0.43	20	C
Potassium	100	16	NA	J
Selenium	1	0.43	2.4	H
Silver	1	0.19	0.24	H
Sodium	50	49	NA	J
Thallium	1	0.57	1.6	H
Vanadium	1	0.11	550	D
Zinc	2	0.98	1,000	H
Zinc (Method 7951)	2	*	1,000	H
Cyanide (Method 9010B)	0.5	---	40	H
TOC (Method 9060)	100	15	NA	K
TPH (Method 8015B)	10000	4000	5	L
GRO	10,000	4,000	5	L
DRO	10,000	4,000	4	L

Fluoride	2.0	0.2	4	A
Total phosphorus	25	6.8	1.5	E
Orthophosphate	5.0	0.18	NA	K

Notes:
The PQLs for waste samples that are to be prepared using the USEPA TCLP procedures are the same as those presented in this table.
DQL indicates data quality limit.
PQL indicates laboratory practical quantitation limits
MDL indicates laboratory detection limits
--- indicates detection limit not provided
MDL studies were performed in 1999.
* indicates the MDL study will be performed prior to sample analysis.
(c) - Value for Chromium IV.
(q) - The following hierarchy was used to determine the appropriate DQL:
1. The lower of Illinois Tiered Approach to Corrective Action (TACO) Program Tier 1 values from Appendix B, Table C or Appendix B, Table A, with adjustments made for additivity for noncarcinogens.
2. For constituents not listed on Appendix B, Table A, Region IX PRGs for residential soil were used.
A - IEPA, 1998, Appendix B, Table A, Value for Class I Groundwater
C - IEPA, 1998, Appendix B, Table A, Value for Inhalation
D - IEPA, 1998, Appendix B, Table A, Value for Ingestion
E - Region IX PRG based on noncarcinogenic effects.
H - IEPA, 1998, Appendix B, Table C. Lowest value was selected.
J - No value is available as this constituent is an essential nutrient.
L - Estimated data quality limits based on previous testing.
NA - Not available.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5C. *USEPA method 8260B detection limits.*

Compound	Water (mg/L)					
	PQLs	MDLs	Surface water DQL (m)	Ground water DQL (a)	Basis	Selected DQL (p)
1,1-Dichloroethane	0.005	0.00052	NA	0.7	B	0.7
1,1,2-Trichloroethane	0.005	0.00047	0.042	0.005	B	0.005
1,2-Dichloroethane	0.005	0.00057	0.099	0.00003	A	0.00003
1,1,1-Trichloroethane	0.005	0.00046	NA	0.2	B	0.2
1,1,2,2-Tetrachloroethane	0.005	0.00075	0.011	0.000055	C(ca)	0.000055
1,2-Dichloroethene (total)	0.005	0.00044	140	0.07(c)	B	0.07
1,2-Dichloropropane	0.005	0.00052	0.039	0.005	B	0.005
1,1-Dichloroethene	0.005	0.00045	0.0032	0.007	B	0.0032
2-Butanone	0.025	0.011	NA	1.9	C(nc)	1.9
2-Hexanone	0.025	0.0044	NA	0.16(g)	C(nc)	0.16
4-Methyl-2-pentanone	0.025	0.0086	NA	0.16	C(nc)	0.16
Acetone	0.050	0.0099	NA	0.7	B	0.7
Benzene	0.0012	0.00027	0.071	0.005	B	0.005
Bromodichloromethane	0.005	0.00035	0.046	0.00002	B	0.00002
Bromoform	0.005	0.00058	0.36	0.0002	B	0.0002
Bromomethane	0.0098	0.0025	NA	0.0098	B	0.0098
Carbon disulfide	0.005	0.0015	NA	0.7	B	0.7
Carbon tetrachloride	0.005	0.00042	0.0044	0.00003	A	0.00003
Chlorobenzene	0.005	0.00063	21	0.1	B	0.1
Chloroethane	0.010	0.0016	NA	12.6(o)	C(ca)	12.6
Chloroform	0.005	0.0009	0.47	0.00002	B	0.00002
Chloromethane	0.010	0.0021	NA	0.0015	C(ca)	0.0015
Cis-1,3-dichloropropene	0.001	0.00047	1.7	0.001	B	0.001
Dibromochloromethane	0.005	0.00051	0.034	0.14	B	0.034
Ethylbenzene	0.005	0.00083	29	0.7	B	0.7
Methylene chloride	0.0047	0.00031	1.6	0.005	B	0.005
Styrene	0.005	0.00098	NA	0.1	B	0.1
Tetrachloroethene	0.005	0.0016	0.00885	0.00001	A	0.00001
Toluene	0.005	0.00051	200	1	B	1
Trans-1,3-dichloropropene	0.005	0.00038	1.7	0.001	B	0.001
Trichloroethene	0.0027	0.00028	0.081	0.005	B	0.005
Vinyl chloride	0.010	0.0005	0.525	0.00006	A	0.00006
Xylenes (total)	0.005	0.0019	NA	10	B	10

Table 5C. *USEPA method 8260B detection limits.*

Compound	Water (mg/L)					
	PQLs	MDLs	Surface water DQL (m)	Ground water DQL (a)	Basis	Selected DQL (p)

Notes:
DQL indicates data quality limits.
PQL indicates laboratory practical quantitation limits.
MDL indicates laboratory detection limits.
MDL studies were performed in 1999.
(a) - The following hierarchy was used to determine the appropriate DQL:
1. ADL value from Appendix A Table H from the Illinois Tiered Approach to Corrective Action (TACO) program.
2. For constituents not on Table H, the value for ClassI GW from Appendix B Table E was used.
3. For constituents with no TACO values, the Region IX PRG for tap water was used.
4. For remaining constituents, a default value equivalent to the lowest DQL for that ty7pe of constituent was used.
(c) - Value for dis-1,2-Dichloroethylene.
(g) - Due to structural similarities, the value for 4-Methyl-2-Pentanone was used.
(m) - Surface water values were obtained from Federal Register, Vol. 63, No. 237. Value for Human Health Consumption of Organisms.
(o) 0 PRG calculated based on equations in PRG table.
(p) - Selected DQL is the lower of the surface water and ground water DQLs.
(ca) - Based on carcinogenic effects.
(nc) - Based on noncarcinogenic effects.
A - IEPA, 1998, Appendix A, Table H, Acceptable Detection Limit (ADL) Value.
B - IEPA, 1998, Appendix B, Table E, Value for Class I Groundwater.
C - Region IX PRG.
NA - Not available.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5D. *USEPA method 8260B detection limits.**

Compound	Soil (mg/kg)			
	PQLs	MDLs	DQL(q)	Basis
1,1-Dichloroethane	0.005	0.00146	1.77	B
1,1,2-Trichloroethane	0.005	0.00096	0.02	A
1,2-Dichloroethane	0.005	0.0012	0.02	A
1,1,1-Trichloroethane	0.005	0.0021	2	A
1,1,2,2-Tetrachloroethane	0.005	0.001	0.36	F
1,2-Dichloroethene (total)	0.005	0.0017	0.0364	B
1,2-Dichloropropane	0.005	0.0014	0.01	B
1,1-Dichloroethene	0.0046	0.0022	0.00462	B
2-Butanone	0.025	0.0033	6,900	E
2-Hexanone	0.025	0.0048	750(m)	E
4-Methyl-2-pentanone	0.025	0.0049	750	E
Acetone	0.050	0.0036	123	B
Benzene	0.005	0.0017	0.03	A
Bromodichloromethane	0.005	0.00088	0.6	A
Bromoform	0.005	0.00082	0.8	A
Bromomethane	0.010	0.0036	3.8	E
Carbon disulfide	0.005	0.0022	4.57	B
Carbon tetrachloride	0.005	0.0019	0.07	A
Chlorobenzene	0.005	0.0013	0.0769	B
Chloroethane	0.010	0.0022	153(p)	F
Chloroform	0.005	0.0017	0.03	C
Chloromethane	0.010	0.0013	1.2	F
Cis-1,3-dichloropropene	0.004	0.00099	0.004	A
Dibromochloromethane	0.005	0.00084	0.4	A
Ethylbenzene	0.005	0.002	1	B
Methylene chloride	0.005	0.0014	0.02	A
Styrene	0.005	0.0018	0.308	B
Tetrachloroethene	0.005	0.003	0.06	A
Toluene	0.005	0.0018	0.923	B
Trans-1,3-dichloropropene	0.004	0.0021	0.004	A
Trichloroethene	0.005	0.0021	0.06	A
Vinyl chloride	0.010	0.0015	0.01	A
Xylenes (total)	0.005	0.003	21.1(d)	B

Table 5D. *USEPA method 8260B detection limits.**

Compound	Soil (mg/kg)			
	PQLs	MDLs	DQL(q)	Basis

Notes:
* indicates that the PQLs and MDLs are based on USEPA Method 5035 preparation for VOCs.

The PQLs for waste samples that are to be prepared using the USEPA TCLP procedures are the same as those presented in this table.
DQL indicated data quality limit.
PQL indicates laboratory practical quantitation limits.
MDL indicates laboratory detection limits.
MDL studies were performed in 1999.
(d) - Value for o-Xylene.
(m) - Due to structural similarieits, the value for 4-Methyl 2-Pentanone was used.
(p) - PRG calculated based on equations in PRG table.
(q) - The following hierarchy was used to determine the appropriate DQL:
1. The lower of Illinois Tiered Approach to Corrective Action (TACO) Program Tier 1 values from Appendix B, Table C or Appendix B, Table A. Region IX PRGs for residential soil were used.
2. For constituents not listed on Appendix B, Table A, Region IX PRGs for residential soil were used.

A - IEPA, 1998, Appendix B, Table A, Value for Class I Groundwater.
B - IEPA, 1998, Appendix B, Table A, Value for Class I Groundwater adjusted for additivity of noncarcinogenic effects.
C - IEPA, 1998, Appendix B, Table A, Value for Inhalation.
E - Region IX PRG based on noncarcinogenic effects.
F - Region IX PRG based on carcinogenic effects.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5E. *USEPA method 8270C detection limits.*

Compound	Water (mg/L)					
	PQLs	MDLs	Surface water DQL (m)	Ground water DQL(a)	Basis	Selected DQL (p)
1,2,4-Trichlorobenzene	0.010	0.00036	0.94	0.07	B	0.07
1,2-Dichlorobenzene	0.010	0.00031	17	0.6	B	0.6
1,3-Dichlorobenzene	0.010	0.00032	2.6	0.075	B	0.075
1,4-Dichlorobenzene	0.010	0.00029	2.6	0.075	B	0.075
2,4,5-Trichlorophenol	0.010	0.00074	9.8	0.7	B	0.7
2,4,6-Trichlorophenol	0.0021	0.00035	0.0065	0.0064	B	0.0064
Bis(2-chloroisopropyl) ether {2,2-oxybis (1-chloropropane)}	0.010	0.00023	170	0.00027	C(ca)	0.00027
2,4-Dichlorophenol	0.010	0.00066	0.79	0.021	B	0.021
2,4-Dinitrotoluene	0.010	0.00041	0.0091	0.00002	B	0.00002
2,6-Dinitrotoluene	0.010	0.00034	NA	0.0001	B	0.0001
2,4-Dinitrophenol	0.014	0.0008	14	0.014	B	0.014
2-Chloronaphthalene	0.010	0.00039	4.3	0.49	C(nc)	0.49
2-Chlorophenol	0.010	0.00024	0.4	0.035	B	0.035
2-Methylnaphthalene	0.010	0.00033	NA	0.025(d)	B	0.025
2-Methylphenol (o-cresol)	0.010	0.00029	NA	0.35	B	0.35
2-Nitroaniline	0.050	0.0053	NA	2.2	C(nc)	2.2
2-Nitrophenol	0.010	0.00036	NA	2.3(h)	C(nc)	2.3
3,3-Dichlorobenzidine	0.020	0.0044	0.000077	0.02	A	0.000077
3-Nitroaniline	0.050	0.005	NA	0.0022(i)	C(nc)	0.0022
4,6-Dinitro-2-methylphenol	0.013	0.005	0.765	NA	E	0.765
4-Bromophenyl phenyl ether	0.001	0.00035	NA	NA	E	NA
4-Chloro-3-methyl-phenol	0.010	0.00033	NA	NA	E	NA
4-Chloroaniline	0.020	0.00098	NA	0.028	B	0.028
4-Chlorophenylphenyl ether	0.010	0.00066	NA	NA	E	NA
4-Methylphenol (p-cresol)	0.010	0.00071	NA	0.35	B	0.35
4-Nitroaniline	0.050	0.0077	NA	0.0022(i)	C(nc)	0.0022
4-Nitrophenol	0.050	0.0049	NA	2.3	C(nc)	2.3
Acenaphthene	0.010	0.00025	2.7	0.42	B	0.42
Acenaphthylene	0.010	0.00033	2.7(b)	0.42(b)	B	0.42
Anthracene	0.010	0.00033	110	2.1	B	2.1
Benzo(a)anthracene	0.010	0.0003	0.000049	0.00013	B	0.000049

Table 5E. *USEPA method 8270C detection limits.*

Compound	Water (mg/L)					
	PQLs	MDLs	Surface water DQL (m)	Ground water DQL(a)	Basis	Selected DQL (p)
Benzo(a)pyrene	0.010	0.00041	0.000049	0.00023	A	0.000049
Benzo(b)fluoranthene	0.010	0.00028	0.000049	0.00017	B	0.000049
Benzo(g,h,i)perylene	0.010	0.00068	NA	0.21(e)	B	0.21
Benzo(k)fluoranthene	0.010	0.00072	0.000049	0.00017	B	0.000049
Bis(2-chloroethoxy) methane	0.010	0.00026	NA	NA	E	NA
Bis(2-ethylhexyl) phthalate	0.0018	0.00048	0.0059	0.006	B	0.0059
Bis(2-chloroethyl ether)	0.010	0.00044	0.0014	0.01	A	0.0014
Butyl benzyl phthalate	0.010	0.00041	5.2	1.4	B	1.4
Carbazole	0.0034	0.00054	NA	0.0034	C(ca)	0.0034
Chrysene	0.010	0.00044	0.000049	0.0015	B	0.000049
Di-n-butyl phthalate	0.010	0.00026	12	0.7	B	0.7
Di-n-octylphthalate	0.010	0.00035	NA	0.14	B	0.14
Dibenz(a,h)anthracene	0.010	0.0008	0.000049	0.0003	A	0.000049
Dibenzofuran	0.010	0.00029	NA	0.024	C(nc)	0.024
Diethylphthalate	0.010	0.00047	120	5.6	B	5.6
Dimethylphthalate	0.010	0.00039	2,900	370	C(nc)	370
Fluoranthene	0.010	0.00033	0.37	0.28	B	0.28
Fluorene	0.001	0.00038	14	0.28	B	0.28
Hexachlorobenzene	0.010	0.00019	0.00000077	0.00006	A	0.00000077
Hexachlorobutadiene	0.010	0.00035	0.05	0.00086	C(ca)	0.00086
Hexachlorocyclopentadiene	0.010	0.0024	17	0.05	B	0.05
Hexachloroethane	0.0019	0.00032	0.0089	0.007	B	0.007
Indeno(1,2,3-cd)pyrene	0.010	0.00056	0.000049	0.00043	B	0.000049
Isophorone	0.010	0.00037	2.6	1.4	B	1.4
N-nitroso-di-n-propylamine	0.010	0.00029	0.0014	0.01	A	0.0014
N-nitrosodiphenylamine	0.005	0.00034	0.016	0.01	B	0.01
Naphthalene	0.010	0.00036	NA	0.025	B	0.025
Nitrobenzene	0.0035	0.00031	1.9	0.0035	B	0.0035
Pentachlorophenol	0.005	0.004	0.0082	0.001	A	0.001
Phenanthrene	0.010	0.00033	110(f)	2.1(f)	B	2.1
Phenol	0.010	0.00028	4,600	0.1	B	0.1
Pyrene	0.010	0.00053	11	0.21	B	0.21

Table 5E. *USEPA method 8270C detection limits.*

Compound	Water (mg/L)					
	PQLs	MDLs	Surface water DQL (m)	Ground water DQL(a)	Basis	Selected DQL (p)

Notes:
DQL indicates data quality limit.
PQL indicates laboratory practical quantitation limits
MDL indicates laboratory detection limits
MDL studies were performed in 1999.
(a) - The following hierarchy was used to determine the appropriate DQL:
1. ADL value from Appendix A, Table H from the Illinois Tiered Approach to Corrective Action (TACO) Program.
2. For constituents not on Table H, the value for Class I GW from Appendix B, Table E was used.
3. For constituents with no TACO values, the Region IX PRG for tap water was used.
4. For remaining constituents, a default value equivalent to the lowest DQL for that type of constituent was used.

(b) - Due to structural similarities, the value for Acenaphthene was used.
(d) - Due to structural similarities, the value for Naphthalene was used.
(h) - Due to structural similarities, the value for 4-Nitrophenol was used.
(i) - Due to structural similarities, the value for 2-Nitroaniline was used.
(m) - Surface water values were obtained from Federal Register, Vol. 63, No. 237. Value for Human Health Consumption of Organisms.
(p) - Selected DQL is the lower of the surface wqter and ground water DQLs.
(ca) - Based on carcinogenic effects.
(nc) - Based on noncarcinogenic effects.
A - IEPA, 1998, Appendix A, Table H, Acceptable Detection Limit (ADL) Value.
B - IEPA, 1998, Appendix B, Table E, Value for Class I Groundwater.
C - Region IX PRG.
NA - Not available.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5F. *USEPA method 8270C detection limits.*

Compound	Soil (mg/kg)			
	PQLs	MDLs	DQL(q)	Basis
1,2,4-Trichlorobenzene	0.170	0.022	2.5	B
1,2-Dichlorobenzene	0.170	0.024	1.7	A
1,3-Dichlorobenzene	0.170	0.031	2(e)	A
1,4-Dichlorobenzene	0.170	0.027	2	A
2,4,5-Trichlorophenol	0.170	0.029	64	H
2,4,6-Trichlorophenol	0.070	0.020	0.07	H
Bis(2-chloroisopropyl) ether {2,2-oxybis (1-chloropropane)}	0.170	0.033	2.54	F
2,4-Dichlorophenol	0.170	0.031	0.69	H
2,4-Dinitrotoluene	0.170	0.040	0.0008	A
2,6-Dinitrotoluene	0.170	0.029	0.0007	A
2,4-Dinitrophenol	0.850	0.150	110	E
2-Chloronaphthalene	0.170	0.024	3,700	E
2-Chlorophenol	0.170	0.032	3.1	H
2-Methylnaphthalene	0.170	0.032	84	A
2-Methylphenol (o-cresol)	0.170	0.032	1.67	B
2-Nitroaniline	0.850	0.042	3.3	E
2-Nitrophenol	0.170	0.019	3,400(n)	E
3,3-Dichlorobenzidine	0.330	0.150	0.007	A
3-Nitroaniline	0.850	0.032	3.3(o)	E
4,6-Dinitro-2-methylphenol	0.850	0.200	NA	K
4-Bromophenyl phenyl ether	0.170	0.024	NA	K
4-Chloro-3-methyl-phenol	0.170	0.049	NA	K
4-Chloroaniline	0.330	0.037	0.35	B
4-Chlorophenylphenyl ether	0.170	0.028	NA	K
4-Methylphenol (p-cresol)	0.170	0.042	1.67(g)	B
4-Nitroaniline	0.850	0.042	3.3(o)	E
4-Nitrophenol	0.850	0.160	3,400	E
Acenaphthene	0.170	0.029	43.8	B
Acenaphthylene	0.170	0.021	438(h)	B
Anthracene	0.170	0.021	12,000	A
Benzo(a)anthracene	0.170	0.020	0.9	D
Benzo(a)pyrene	0.090	0.029	0.09	D
Benzo(b)fluoranthene	0.170	0.023	0.9	D

Table 5F. *USEPA method 8270C detection limits.*

Compound	Soil (mg/kg)			
	PQLs	MDLs	DQL(q)	Basis
Benzo(g,h,i)perylene	0.170	0.026	177(A)	B,D
Benzo(k)fluoranthene	0.170	0.026	9	D
Bis(2-chloroethoxy) methane	0.170	0.029	NA	K
Bis(2-ethylhexyl) phthalate	0.170	0.045	46	A
Bis(2-chloroethyl ether)	0.170	0.026	0.0004	A
Butyl benzyl phthalate	0.170	0.042	930	A
Carbazole	0.170	0.022	0.6	A
Chrysene	0.170	0.021	88	D
Di-n-butyl phthalate	0.170	0.028	2,300	A
Di-n-octylphthalate	0.170	0.054	123	B,D
Dibenz(a,h)anthracene	0.090	0.052	0.09	D
Dibenzofuran	0.170	0.030	210	E
Diethylphthalate	0.170	0.032	470	A
Dimethylphthalate	0.170	0.025	100,000	G
Fluoranthene	0.170	0.031	238	B,D
Fluorene	0.170	0.031	56	B
Hexachlorobenzene	0.070	0.045	0.07	D
Hexachlorobutadiene	0.170	0.023	5.7	F
Hexachlorocyclopentadiene	0.170	0.051	3.33	B,C
Hexachloroethane	0.170	0.024	0.5	A
Indeno(1,2,3-cd)pyrene	0.170	0.067	0.9	D
Isophorone	0.170	0.026	8	A
N-nitroso-di-n-propylamine	0.170	0.032	0.00005	A
N-nitrosodiphenylamine	0.170	0.025	1	A
Naphthalene	0.170	0.025	84	B
Nitrobenzene	0.170	0.027	0.00769	B
Pentachlorophenol	0.850	0.180	0.02	H
Phenanthrene	0.170	0.017	12,000(b)	A
Phenol	0.170	0.042	14.3	B
Pyrene	0.170	0.063	177	B,D

Table 5F. *USEPA method 8270C detection limits.*

Compound	Soil (mg/kg)			
	PQLs	MDLs	DQL(q)	Basis

Notes:
The PQLs for waste samples that are to be prepared using the USEPA TCLP procedures are the same as those presented in this table.
DQL indicates data quality limits.
PQL indicates laboratory practical quantitation limits.
MDL indicates laboratory detection limits.
MDL studies were performed in 1999.
(a) - Due to structural similarities, the value for Pyrene was used.
(b) - Due to structural similarities, the value for Anthracene was used.
(e) - IEPA, 1998, No Appendix Table B value available; therefore, due to structural similarities, value for 1,2-Dichlcorobenzene was used.
(g) - Due to structural similarities, the value for 2-Methylphenol was used.
(h) - Due to structural similarities, the value for Acenaphthene was used.
(n) - Due to structural similarities, the value for 4-Nitrophenol was used.
(o) - Due to structural similarities, the value for 2-Nitroaniline was used.
(q) - The following hierarchy was used to determine the appropriate DQL:
1. The lower of Illinois Tiered Approach to Corrective Action (TACO) Program Tier 1 values from Appendix B, Table C or Appendix B, Table A, with adjustments made for additivity for noncarcinogens.
2. For constituents not listed on Appendix B, Table A, Region IX PRGs for residential soil were used.

A - IEPA, 1998, Appendix B, Table A, Value for Class I Groundwater
B - IEPA, 1998, Appendix B, Table A, Value for Class I Groundwater adjusted for additivity of noncarcinogenic effects
C - IEPA, 1998, Appendix B, Table A, Value for Inhalation
D - IEPA, 1998, Appendix B, Table A, Value for Ingestion
E - Region IX PRG based on noncarcinogenic effects
G - Region IX PRG based on ceiling limit
H - IEPA, 1998, Appendix B, Table C. Lowest value was selected.
K - No toxicity information is available for this constituent; therefore, DQL was not developed.
NA - Not available
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5G. *USEPA method 8081a, 680 and 8151A detection limits.*

Compound	Water (mg/L)					
	PQLs	MDLs	Surface water DQL(m)	Ground water DQL(a)	Basis	Selected DQL(p)
Aldrin	0.0005	0.0000012	0.00000014	0.00004	A	0.00000014
Alpha-BHC	0.000039	0.0000006	0.000013	0.00003	A	0.000013
Beta-BHC	0.000014	0.00000085	0.000046	0.00003(n)	A	0.00003
Delta-BHC	0.000012	0.00000084	NA	0.00003(n)	A	0.00003
Gamma-BHC (lindane)	0.000019	0.00000052	0.000063	0.0002	B	0.000063
Alpha-chlordane	0.00005	0.000001	0.0000022(j)	0.00014(j)	A	0.0000022
Gamma-chlordane	0.00005	0.00000078	0.0000022(j)	0.00014(j)	A	0.0000022
4,4-DDD	0.0001	0.0000024	0.00000084	0.00011	B	0.00000084
4,4-DDE	0.0001	0.0000014	0.00000059	0.00004	B	0.00000059
4,4-DDT	0.0001	0.0000038	0.00000059	0.00012	B	0.00000059
Dieldrin	0.0001	0.0000024	0.00000014	0.00002	A	0.00000014
Endosulfan I	0.00005	0.00000097	0.24	0.042(k)	B	0.042
Endosulfan II	0.0001	0.0000013	0.24	0.042(k)	B	0.042
Endosulfan sulfate	0.0001	0.0000026	0.24	0.042(k)	B	0.042
Endrin	0.0001	0.0000023	0.00081	0.002	B	0.00081
Endrin aldehyde	0.0001	0.0000017	0.00081	0.002(l)	B	0.00081
Endrin ketone	0.0001	0.00000066	0.00081(l)	0.002(l)	B	0.00081
Heptachlor epoxide	0.00005	0.00000088	0.00000011	0.00032	A	0.00000011
Heptachlor	0.00005	0.0000011	0.00000021	0.00003	A	0.00000021
Methoxychlor	0.0005	0.0000086	NA	0.04	B	0.04
Toxaphene	0.0005	0.00062	0.00000075	0.00086	A	0.00000075
2,4-D	0.0005	0.00016	NA	0.07	B	0.07
2,4-DB	0.0005	0.00015	NA	292(o)	C(nc)	292
2,4,5-TP (silvex)	0.0005	0.000048	NA	0.05	B	0.05
2,4,5-T	0.0005	0.000087	NA	782(o)	C(nc)	782
Dalapon	0.120	0.00074	NA	0.2	B	0.2
Dicamba	0.0012	0.00007	NA	1.1	C(nc)	1.1
Dichlorprop	0.006	0.00064	NA	NA	E	NA
Dinoseb	0.006	0.00088	NA	0.007	B	0.007
MCPA	0.120	0.120	NA	18.3(o)	C(nc)	18.3
MCPP	0.120	0.044	NA	36.5(o)	C(nc)	36.5
4-Nitrophenol	2.300@#	NA	NA	2.3	C(nc)	2.3

Table 5G. *USEPA method 8081a, 680 and 8151A detection limits.*

Compound	Water (mg/L)					
	PQLs	MDLs	Surface water DQL(m)	Ground water DQL(a)	Basis	Selected DQL(p)
Pentachlorophenol	0.00028	0.000043	0.0082	0.001	A	0.001
Monochlorobiphenyls	0.0003	0.000044	0.00000017	0.0005	B	0.00000017
Dichlorobiphenyls	0.0003	0.000035	0.00000017	0.0005	B	0.00000017
Trichlorobiphenyls	0.0003	0.000035	0.00000017	0.0005	B	0.00000017
Tetrachlorobiphenyls	0.0006	0.000053	0.00000017	0.0005	B	0.00000017
Pentachlorobiphenyls	0.0006	0.000029	0.00000017	0.0005	B	0.00000017
Hexachlorobiphenyls	0.0006	0.000037	0.00000017	0.0005	B	0.00000017
Heptachlorobiphenyls	0.0009	0.000042	0.00000017	0.0005	B	0.00000017
Octachlorobiphenyls	0.0009	0.000064	0.00000017	0.0005	B	0.00000017
Nonachlorobiphenyls	0.0015	0.00011	0.00000017	0.0005	B	0.00000017
Decachlorobiphenyls	0.0015	0.00011	0.00000017	0.0005	B	0.00000017

Notes:
DQL indicated data quality limits.
PQL indicates laboratory practical quantitation limits.
MDL indicates laboratory detection limits.
* indicates estimated PQLs based on estimated MDLs.
@ indicates value can be determined at or below listed PQL by EPA Method 8270.
MDL studies were performed in 1999.
(a) - The following hierarchy was used to determine the appropriate DQL:
1. ADL value from Appendix A, Table H from the Illinois Tiered Approach to Corrective Action (TACO) Program.
2. For constituents not on Table H, the value for Class I GW from Appendix B, Table E was used.
3. For constituents with no TACO values, the Region IX PRG for tap water was used.
4. For remaining constituents, a default value equivalent to the lowest DQL for that type of constituent was used.

(h) - Due to structural similarities, the value for 4-Nitrophenol was used.
(j) - Due to structural similarities, the value for Chlordane was used.
(k) - Due to structural similarities, the value for Endosulfan was used.
(m) - Surface water values were obtained from Federal Register, Vol. 63, No. 237. Value for Human Health Consumption of Organisms.
(n) - Due to structural similarities, the value for alpha-BHC was used.
(o) - PRG calculated based on equations in PRG table.
(p) - Selected DQL is the lower of the surface water and ground water DQLs.
(nc) - Based on noncarcinogenic effects.
A - IEPA, 1998, Appendix A, Table H, Acceptable Detection Limit (ADL) Value.
B - IEPA, 1998, Appendix B, Table E, Value for Class I Groundwater.
C - Region IX PRG.
E - No toxicity information is available for this constituent; therefore, DQL was not developed.
NA - Not available.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5H. *USEPA method 8081a, 680 and 8151A detection limits.*

Compound	Soil (mg/kg)			
	PQLs	MDLs	DQLs	Basis
Aldrin	0.0017	0.00014	0.040	D
Alpha-BHC	0.0005	0.000031	0.0005	A
Beta-BHC	0.0005	0.000054	0.0005(j)	A
Delta-BHC	0.0005	0.000035	0.0005(j)	A
Gamma-BHC (lindane)	0.0017	0.000037	0.009	A
Alpha-chlordane	0.0017	0.000042	0.5(i)	D
Gamma-chlordane	0.0017	0.000052	0.5(i)	D
4,4-DDD	0.0033	0.0001	3	D
4,4-DDE	0.0033	0.000064	2	D
4,4-DDT	0.0033	0.000044	2	D
Dieldrin	0.0033	0.000042	0.004	A
Endosulfan I	0.0017	0.00006	1.38(k)	B
Endosulfan II	0.0033	0.000074	1.38(k)	B
Endosulfan sulfate	0.0033	0.000069	1.38(k)	B
Endrin	0.0033	0.000032	0.0769	B
Endrin aldehyde	0.0033	0.000077	0.0769(l)	B
Endrin ketone	0.0033	0.000083	0.0769(l)	B
Heptachlor epoxide	0.0017	0.00004	0.07	D
Heptachlor	0.0017	0.000062	0.1	C,D
Methoxychlor	0.017	0.00077	22.9	B
Toxaphene	0.170	0.018	0.6	D
Monochlorobiphenyls	0.01	0.00068	1	M
Dichlorobiphenyls	0.01	0.00076	1	M
Trichlorobiphenyls	0.01	0.00068	1	M
Tetrachlorobiphenyls	0.02	0.0013	1	M
Pentachlorobiphenyls	0.02	0.00083	1	M
Hexachlorobiphenyls	0.02	0.00089	1	M
Heptachlorobiphenyls	0.03	0.0016	1	M
Octachlorobiphenyls	0.03	0.00095	1	M
Nonachlorobiphenyls	0.05	0.0019	1	M
Decachlorobiphenyls	0.05	0.0019	1	M
2,4-D	0.0083	0.0016	0.136	B
2,4-DB	0.0083	0.0064	440	E
2,4,5-TP (silvex)	0.0083	0.0009	11	H

Table 5H. *USEPA method 8081a, 680 and 8151A detection limits.*

Compound	Soil (mg/kg)			
	PQLs	MDLs	DQLs	Basis
2,4,5-T	0.0083	0.001	782(p)	E
Dalapon	0.065	0.023	0.0654	B
Dicamba	0.020	0.0012	1600	E
Dichlorprop	0.100	0.0027	NA	K
Dinoseb	0.100	0.0083	0.25	H
MCPA	2.000	0.740	39.1(p)	E
MCPP	2.000	0.400	78.2(p)	E
4-Nitrophenol	3400.00@#	NA	3400	E
Pentachlorophenol	*0.017*	*0.00096*	*0.02*	H

Notes:
The PQLs for waste samples that are to be prepared using the USEPA TCLP procedures are the same as those presented in this table.
DQL indicates data quality limits.
PQL indicates laboratory practical quantitation limits.
MDL indicates laboratory detection limits.
# indicates estimated PQLs are based on estimated MDLs.
@ indicates value can be determined at or below listed PQL by EPA Method 8270.
MDL studies were performed in 1999.
(i) - Due to structural similarities, the value for Chlordane was used.
(j) - Due to structural similarities, the value for alpha-BHC was used.
(k) - Due to structural similarities, the value for Endosulfan was used.
(l) - Due to structural similarities, the value for Endrin was used.
(p) - PRG calculated based on equations in PRG table.
(q) - The following hierarchy was used to determine the appropriate DQL:
1. The lower of Illinois Tiered Approach to Corrective Action (TACO) Program Tier 1 values from Appendix B, Table C or Appendix B, Table A, with adjustments made for additivity for noncarcinogens.
2. For constituents not listed on Appendix B, Table A, Region IX PRGs for residential soil were used.

A - IEPA, 1998, Appendix B, Table A, Value for Class I Groundwater
B - IEPA, 1998, Appendix B, Table A, Value for Class I Groundwater adjusted for additivity of noncarcinogenic effects.
C - IEPA, 1998, Appendix B, Table A, Value for Inhalation
D - IEPA, 1998, Appendix B, Table A, Value for Ingestion
E - Region IX PRG based on noncarcinogenic effects
H - IEPA, 1998, Appendix B, Table C. Lowest value was selected.
M - USEPA, 1998f, PCB Mega Rule
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5l. *USEPA method 8280A detection limits.*

Parameter	Water PQLs/CRQLs (mg/L)	Water MDLs (mg/L)	Surface water DLQ(m)	Ground water (DQL(a)	Basis	Selected DQL(p)
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.000010	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	0.000050	*	0.000000000014	0.00000045	C	0.000000000014
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	0.000010	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	0.000025	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	0.000010	*	0.000000000014	0.00000045	C	0.000000000014

Table 5l. *USEPA method 8280A detection limits.*

Parameter	Water PQLs/CRQLs (mg/L)	Water MDLs (mg/L)	Surface water DLQ(m)	Ground water (DQL(a)	Basis	Selected DQL(p)

Notes:
DQL indicates data quality limit.
CRQL indicates contract required quantitation limit.
MDL indicates method detection limit.
ng/l indicates nanogram per liter.
* The traditional definition of MDL, as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, is difficult to apply to PCDD/PCDF by HRGC-HRMS. Although the laboratory performs the MDL study according to 40 CFR, Part 136, Appendix B, the MDL value is not used in reporting the concentration of PCDDs or PCDFs. The MDL studies are scheduled using blank matrix material (such as sand) and are usually analyzed on one instrument. The results reported are specific of the conditions of that specific instrument on that given day and cannot be representative of all analyses performed by the method.

For the PCDD/PCDF analysis, Triangle Laboratory, Inc. reports the actual limits of detection, which is defined as the lowest concentration of an analyte that can pass the qualitative criteria of identification. For PCDD/PCDF by HRGC-HRMS, the criteria of identification includes the exact mass channel selection criteria, retention time criteria, signal-to-noise ratio, and ion abundance criteria. A peak in a high resolution channel with the right retention time to be analyte A, having a signal-to-noise ratio of $\geq$ 2.5, and having the ratio of the two monitored ions within the method specified limits to be analyte A, is judged to be analyte A. The analyte is present at a level equal to or greater than the limit of detection and must be reported as per the method. However, that does not indicate that the concentration of analyte A can be measured with acceptable accuracy. If the apparent concentration is within the range of the calibration curve, the level is reported as such. If the apparent concentration is below or above the calibration range, it is flagged as an "estimated" concentration.
(a) - The following hierarchy was used to determine the appropriate DQL:
1. ADL value from Appendix A, Table H from the Illinois Tiered Approach to Corrective Action (TACO) Program.
2. For constituents not on Table H, the value for Class I GW from Appendix B, Table E was used.
3. For constituents with no TACO values, the Region IX PRG for tap water was used.
4. For remaining constituents, a default value equivalent to the lowest DQL for that type of constituent was used.

(m) - Surface water values were obtained from Federal Register, Vol. 63, No. 237. Value for Human Health Consumption of Organisms.
(p) - Selected DQL is the lower of the surface water and ground water DQLs.
C - Region IX PRG.
Source: Triangle Laboratories, Inc.

Table 5J. *USEPA method 8280A detection limits.*

Parameter	Soil CRQL (mg/kg), wet wt	Soil MDL (mg/kg), wet wt	Soil DQL(q)	Basis
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.001	*	0.001	I
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	0.0025	*	0.001	I
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.0025	*	0.001	I
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.0025	*	0.001	I
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	0.0025	*	0.001	I
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	0.0025	*	0.001	I
1,2,3,4,6,7,8,9- Octachlorodibenzo-p-dioxin (OCDD)	0.005	*	0.001	I
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	0.001	*	0.001	I
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	0.0025	*	0.001	I
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	0.0025	*	0.001	I
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	0.0025	*	0.001	I
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.0025	*	0.001	I
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.0025	*	0.001	I
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	0.0025	*	0.001	I
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	0.0025	*	0.001	I
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	0.0025	*	0.001	I
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	0.005	*	0.001	I

Table 5J. *USEPA method 8280A detection limits.*

Parameter	Soil CRQL (mg/kg), wet wt	Soil MDL (mg/kg), wet wt	Soil DQL(q)	Basis

Notes:
The CRQLs for waste samples that are to be prepared using the USEPA TCLP procedures are the same as those presented in this table.
DQL indicates data quality limit.
CRQL indicates contract required quantitation limit.
MDL indicates method detection limit.
ng/Kg indicates nanogram per kilogram.
* The traditional definition of MDL, as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, is difficult to apply to PCDD/PCDF by HRGC-HRMS. Although the laboratory performs the MDL study according to 40 CFR, Part 136, Appendix B, the MDL value is not used in reporting the concentration of PCDDs or PCDFs. The MDL studies are scheduled using blank matrix material (such as sand) and are usually analyzed on one instrument. The results reported are specific of the conditions of that specific instrument on that given day and cannot be representative of all analyses performed by the method.

For the PCDD/PCDF analysis, Triangle Laboratory, Inc. reports the actual limits of detection, which is defined as the lowest concentration of an analyte that can pass the qualitative criteria of identification. For PCDD/PCDF by HRGC-HRMS, the criteria of identification includes the exact mass channel selection criteria, retention time criteria, signal-to-noise ratio, and ion abundance criteria. A peak in a high resolution channel with the right retention time to be analyte A, having a signal-to-noise ratio of $\geq$ 2.5, and having the ratio of the two monitored ions within the method specified limits to be analyte A, is judged to be analyte A. The analyte is present at a level equal to or greater than the limit of detection and must be reported as per the method. However, that does not indicate that the concentration of analyte A can be measured with acceptable accuracy. If the apparent concentration is within the range of the calibration curve, the level is reported as such. If the apparent concentration is below or above the calibration range, it is flagged as an "estimated" concentration.
(q) - The following hierarchy was used to determine the appropriate DQL:
1. The lower of Illinois Tiered Approach to Corrective Action (TACO) Program Tier 1 values from Appendix B, Table C or appendix B, Table A, with adjustments made for additivity for noncarcinogens.
2. For constituents not listed on Appendix B, Table A, Region IX PRGs for residential soil were used.
I - USEPA, 1998g, Value for Dioxins.
Source: Triangle Laboratories, Inc.

Table 5K. *USEPA method 8290 detection limits.*

Parameter	Water CRQLs (mg/L)	Water MDLs (mg/L)	Surface water DQL(m)	Ground water DQL(a)	Basis	Selected DQL(p)
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.00000001	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,6,7,8-Heptachlorodichlorodibenzo-p-dioxin (HpCDD)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	0.0000001	*	0.000000000014	0.00000045	C	0.000000000014
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	0.00000005	*	0.000000000014	0.00000045	C	0.000000000014
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	0.0000001	*	0.000000000014	0.00000045	C	0.000000000014

Table 5K. *USEPA method 8290 detection limits.*

Parameter	Water CRQLs (mg/L)	Water MDLs (mg/L)	Surface water DQL(m)	Ground water DQL(a)	Basis	Selected DQL(p)

Notes:
DQL indicates data quality limit.
CRQL indicates contract required quantitation limit.
MDL indicates method detection limit.
ng/l indicates nanogram per liter.
* The traditional definition of MDL, as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, is difficult to apply to PCDD/PCDF by HRGC-HRMS. Although the laboratory performs the MDL study according to 40 CFR, Part 136, Appendix B, the MDL value is not used in reporting the concentration of PCDDs or PCDFs. The MDL studies are scheduled using blank matrix material (such as sand) and are usually analyzed on one instrument. The results reported are specific of the conditions of that specific instrument on that given day and cannot be representative of all analyses performed by the method.

For the PCDD/PCDF analysis, Triangle Laboratory, Inc. reports the actual limits of detection, which is defined as the lowest concentration of an analyte that can pass the qualitative criteria of identification. For PCDD/PCDF by HRGC-HRMS, the criteria of identification includes the exact mass channel selection criteria, retention time criteria, signal-to-noise ratio, and ion abundance criteria. A peak in a high resolution channel with the right retention time to be analyte A, having a signal-to-noise ratio of $\geq$ 2.5, and having the ratio of the two monitored ions within the method specified limits to be analyte A, is judged to be analyte A. The analyte is present at a level equal to or greater than the limit of detection and must be reported as per the method. However, that does not indicate that the concentration of analyte A can be measured with acceptable accuracy. If the apparent concentration is within the range of the calibration curve, the level is reported as such. If the apparent concentration is below or above the calibration range, it is flagged as an "estimated" concentration.
(a) - The following hierarchy was used to determine the appropriate DQL:
1. ADL value from Appendix A, Table H from the Illinois Tiered Approach to Corrective Action (TACO) Program.
2. For constituents not on Table H, the value for Class I GW from Appendix B, Table E was used.
3. For constituents with no TACO values, the Region IX PRG for tap water was used.
4. For remaining constituents, a default value equivalent to the lowest DQL for that type of constituent was used.

(m) - Surface water values were obtained from Federal Register, Vol. 63, No. 237. Value for Human Health Consumption of Organisms.
(p) - Selected DQL is the lower of the surface water and ground water DQLs.
C - Region IX PRG.
Source: Triangle Laboratories, Inc.

Table 5L. *USEPA method 8290 detection limits.*

Parameter	Soil CRQL (mg/kg), wet wt	Soil MDL (mg/kg), wet wt	Soil DQL (q)	Basis
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.000001	*	0.001	I
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	0.000005	*	0.001	I
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.000005	*	0.001	I
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.000005	*	0.001	I
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	0.000005	*	0.001	I
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	0.000005	*	0.001	I
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	0.000010	*	0.001	I
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	0.000001	*	0.001	I
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	0.000005	*	0.001	I
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	0.000005	*	0.001	I
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	0.000005	*	0.001	I
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.000005	*	0.001	I
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.000005	*	0.001	I
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	0.000005	*	0.001	I
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	0.000005	*	0.001	I
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	0.000005	*	0.001	I
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	0.000010	*	0.001	I

Table 5L. *USEPA method 8290 detection limits.*

Parameter	Soil CRQL (mg/kg), wet wt	Soil MDL (mg/kg), wet wt	Soil DQL (q)	Basis

Notes:
DQL indicates data quality limit.
CRQL indicates contract required quantitation limit.
MDL indicates method detection limit.
ng/Kg indicates nanogram per kilogram.
* The traditional definition of MDL, as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, is difficult to apply to PCDD/PCDF by HRGC-HRMS. Although the laboratory performs the MDL study according to 40 CFR, Part 136, Appendix B, the MDL value is not used in reporting the concentration of PCDDs or PCDFs. The MDL studies are scheduled using blank matrix material (such as sand) and are usually analyzed on one instrument. The results reported are specific of the conditions of that specific instrument on that given day and cannot be representative of all analyses performed by the method.

For the PCDD/PCDF analysis, Triangle Laboratory, Inc. reports the actual limits of detection, which is defined as the lowest concentration of an analyte that can pass the qualitative criteria of identification. For PCDD/PCDF by HRGC-HRMS, the criteria of identification includes the exact mass channel selection criteria, retention time criteria, signal-to-noise ratio, and ion abundance criteria. A peak in a high resolution channel with the right retention time to be analyte A, having a signal-to-noise ratio of $\geq$ 2.5, and having the ratio of the two monitored ions within the method specified limits to be analyte A, is judged to be analyte A. The analyte is present at a level equal to or greater than the limit of detection and must be reported as per the method. However, that does not indicate that the concentration of analyte A can be measured with acceptable accuracy. If the apparent concentration is within the range of the calibration curve, the level is reported as such. If the apparent concentration is below or above the calibration range, it is flagged as an "estimated" concentration.
(q) - The following hierarchy was used to determine the appropriate DQL:
1. The lower of Illinois Tiered Approach to Corrective Action (TACO) Program Tier 1 values from Appendix B, Table C or Appendix B, Table A, with adjustments made for additivity for noncarcinogens.
2. For constituents not listed on Appendix B, Table A, Region IX PRGs for residential soil were used.
I - USEPA, 1998g, Value for Dioxins.
Source: Triangle Laboratories, Inc.

Table 5M. *USEPA method TO-13 detection limits*

Compound	Air (μg)			
	PQLs	MDLs	DQLs	Basis
Acenaphthene	10	4.4	220	A
Acenaphthylene	10	4.1	220(i)	A
Anthracene	10	3.8	1,100	A
Benzo(a)anthracene	10	2.7	0.022	B
Benzo(b)fluoranthene	10	3.0	0.022	B
Benzo(k)fluoranthene	10	4.9	0.22	B
Benzo(a)pyrene	10	2.9	0.0022	B
Benzo(g,h,i)perylene	10	2.2	110(j)	A
Benzyl alcohol	10	2.4	1,100	A
Bis(2-chloroethoxy)methane	10	2.5	NA	C
Bis(2-chloroethyl)ether	10	2.2	0.0058	B
Bis(2-chloroisopropyl)ether	10	3.3	0.19(b)	B
Bis(2-ethylhexyl)phthalate	10	4.9	0.48	B
4-Bromophenyl phenyl ether	10	3.9	NA	C
Butylbenzyl phthalate	10	2.8	730	A
4-Chloroaniline	15	2.6	15	A
4-Chloro-3-methyl phenol	10	2.6	NA	C
2-Chloronapthalene	10	2.8	290	A
2-Chlorophenol	10	2.7	18	A
4-Chlorophenyl phenyl ether	10	4.2	NA	C
Chrysene	10	2.4	2.2	B
Dibenz(a,h)anthracene	10	2.4	0.0022	B
Dibenzofuran	10	4.7	15	A
1,2-Dichlorobenzene	10	3.4	210	A
1,3-Dichlorobenzene	8.4	3.1	8.4	A
1,4-Dichlorobenzene	10	3.3	0.28	B
3,3'-Dichlorobenzidine	10	5.6	0.015	B
2,4-Dichlorophenol	10	2.7	11	A
Diethylphthalate	10	3.4	2,900	A
2,4-Dimethylphenol	10	2.5	73	A
Dimethylphthalate	10	2.9	37,000	B
Di-n-butylphthalate	10	2.0	370	A
2,4-Dinitrotoluene	10	4.2	7.3	A
2,6-Dinitrotoluene	10	3.2	3.7	A

Table 5M. *USEPA method TO-13 detection limits*

Compound	Air (μg)			
	PQLs	MDLs	DQLs	Basis
Di-n-octyl phthalate	10	5.9	73	A
Fluoranthene	10	3.8	150	A
Fluorene	10	5.1	150	A
Hexachlorobenzene	10	4.7	0.0042	B
Hexachlorobutadiene	10	4.4	0.087	B
Hexachloroethane	10	2.5	0.48	B
Indeno(1,2,3-cd)pyrene	10	2.6	0.022	B
Isophorone	10	3.9	7.1	B
2-Methyl naphthalene	10	8.0	3.1(f)	A
2-Methylphenol	10	3.0	180	A
4-Methylphenol	10	4.8	18	A
Naphthalene	10	6.5	3.1	A
2-Nitroaniline	50	2.5	0.21	A
3-Nitroaniline	50	2.4	0.21(h)	A
4-Nitroaniline	50	2.0	0.21(h)	A
Nitrobenzene	10	5.0	2.1	A
2-Nitrophenol	10	2.4	230(g)	A
N-nitrosodiphenylamine	10	2.8	1.4	B
N-nitrosodi-n-propylamine	10	3.0	0.00096	B
Phenanthrene	10	3.6	1,100(k)	A
Phenol	10	5.8	2,200	A
Pyrene	10	3.7	110	A
1,2,4-Trichlorobenzene	10	3.8	210	A
2,4,5-Trichlorophenol	10	4.2	370	A
2,4,6-Trichlorophenol	10	3.8	0.62	B

Table 5M. *USEPA method TO-13 detection limits*

Compound	Air (μg)			
	PQLs	MDLs	DQLs	Basis

Notes:
DQL indicates data quality limit.
PQL indicates laboratory practical quantitation limits.
MDL indicates laboratory detection limits.
MDL studies were performed in 1999.
(f) - Due to structural similarities, the value for naphthalene was used.
(g) - Due to structural similarities, the value for 4-nitrophenol was used.
(h) - Due to structural similarities, the value for 2-Nitroaniline was used.
(i) - Due to structural similarities, the value for acenaphthene was used.
(j) - Due to structural similarities, the value for pyrene was used.
(k) - Due to structural similarities, the value for anthracene was used.
A - Region IX PRG, based on non-carcinogenic effects.
B - Region IX PRG, based on carcinogenic effects.
C - No toxicological value available.
NA - Not available.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5N. *USEPA method TO-1 detection limits*

	Air (μg)			
Compound	**PQLs**	**MDLs**	**DQLs**	**Basis**
Dichlorodifluoromethane	0.20	0.05	210	A
Chloromethane	0.20	0.04	1.1	B
Vinyl chloride	0.20	0.08	0.022	B
Bromomethane	0.20	0.04	5.2	A
Chloroethane	0.20	0.07	NA	
Trichlorofluoromethane	0.20	0.04	730	A
1,1-Dichloroethene	0.10	0.02	0.038	B
Methylene chloride (dichloromethane)	0.10	0.01	4.1	B
Trans-1,2-dichloroethene	0.10	0.01	73	A
1,1-Dichloroethane	0.10	0.01	520	A
2,2-Dichloropropane	0.10	0.02	NA	C
Cis-1,2-dichloroethene	0.10	0.01	37	A
Chloroform	0.10	0.01	0.084	B
Bromochloromethane	0.10	0.01	NA	C
1,1,1-Trichloroethane	0.10	0.01	1,000	A
1,1-Dichloropropylene	0.10	0.02	NA	C
Carbon tetrachloride	0.10	0.01	0.13	B
1,2-Dichloroethane	0.10	0.01	0.074	B
Benzene	0.10	0.01	0.23	B
Trichloroethylene	0.10	0.01	1.1	B
1,2-Dichloropropane	0.10	0.01	0.099	B
Bromodichloromethane	0.10	0.03	0.11	B
Dibromomethane	0.10	0.02	37	A
Trans-1,3-dichloropropene	0.10	0.01	0.052(e)	B
Toluene	0.10	0.01	400	A
Cis-1,3-dichloropropene	0.10	0.01	0.052(e)	B
1,1,2-Trichloroethane	0.10	0.01	0.12	B
1,3-Dichloropropane	0.10	0.02	NA	C
Tetrachloroethene	0.10	0.01	3.3	B
Dibromochloromethane	0.10	0.02	0.08	B
1,2-Dibromomethane	0.10	0.02	0.0087	B
Chlorobenzene	0.10	0.01	21	A
1,1,1,2-Tetrachloroethane	0.10	0.02	0.26	B
Ethylbenzene	0.10	0.06	1,100	A

Table 5N. *USEPA method TO-1 detection limits*

	Air (μg)			
Compound	**PQLs**	**MDLs**	**DQLs**	**Basis**
M&p-xylene	0.10	0.01	730	A
o-Xylene	0.10	0.01	730	A
Styrene	0.10	0.01	1,100	A
Isopropylbenzene	0.10	0.01	37	A
Bromoform	0.10	0.01	1.7	B
1,1,2,2-Tetrachloroethane	0.10	0.01	0.033	B
1,2,3-Trichloropropane	0.10	0.01	0.00096	B
n-Propylbenzene	0.10	0.01	37	A
Bromobenzene	0.10	0.01	10	A
1,3,5-Trimethylbenzene	0.10	0.01	6.2	A
2-Chlorotoluene	0.10	0.01	73	A
4-Chlorotoluene	0.10	0.01	73(n)	A
t-Butylbenzene	0.10	0.01	37	A
1,2,4-Trimethylbenzene	0.10	0.01	6.2	A
s-Butylbenzene	0.10	0.01	37	A
p-Isopropyltoluene	0.10	0.01	NA	C
1,3-Dichlorobenzene	0.10	0.01	8.4	A
1,4-Dichlorobenzene	0.10	0.01	0.28	B
n-Butylbenzene	0.10	0.01	37	A
1,2-Dichlorobenzene	0.10	0.01	210	A
1,2-Dibromo-3-chloropropane	0.10	0.02	0.21	A
1,2,4-Trichlorobenzene	0.10	0.01	210	A
Hexachlorobutadiene	0.10	0.02	0.087	B
Naphthalene	0.10	0.02	3.1	A
1,2,3-Trichlorobenzene	0.10	0.02	NA	C
Acetone	1.0	0.21	370	A
2-Butanone (MEK)	1.0	0.09	1,000	A
Vinyl acetate	0.10	0.01	210	A
4-Methyl-2-pentanone (MIBK)	1.0	0.16	83	A
2-Hexanone	1.0	0.09	83(d)	A
Carbon disulfide	0.10	0.02	730	A

Table 5N. *USEPA method TO-1 detection limits*

	Air (μg)			
Compound	**PQLs**	**MDLs**	**DQLs**	**Basis**

Notes:
DQL indicates data quality limit.
PQL indicates laboratory practical quantitation limits.
MDL indicates laboratory detection limits.
MDL studies were performed in 1999.
(d) - Due to structural similarities, the value for 4-methyl-2-pentanone was used.
(e) - Value for 1,3-dichloropropene.
A - Region IX PRG, based on non-carcinogenic effects.
B - Region IX PRG, based on carcinogenic effects.
NA - Not available.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5O. *USEPA method TO-4 detection limits*

Compound	Air (μg)			
	PQLs	MDLs	DQLs	Basis
PCB-1016	1.0	0.15	0.0034	B
PCB-1221	1.0	0.27	0.0034	B
PCB-1232	1.0	0.21	0.0034	B
PCB-1242	1.0	0.25	0.0034	B
PCB-1248	1.0	0.18	0.0034	B
PCB-1254	1.0	0.11	0.0034	B
PCB-1260	1.0	0.12	0.0034	B

Notes:
DQL indicates data quality limit.
PQL indicates laboratory practical quantitation limits
MDL indicates laboratory detection limits
MDL studies were performed in 1999.
B - Region IX PRG, based on carcinogenic effects.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 5P. ***USEPA method TO-9 detection limits.***

	Air (pg)			
Parameter	**PQLs**	**MDLs**	**DQLs**	**Basis**
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	50	---	4.50E-08	B
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	250	---	4.50E-08	B
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	250	---	4.50E-08	B
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	250	---	4.50E-08	B
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	250	---	4.50E-08	B
1,2,3,4,6,7,8-Heptachlorodichlorodibenzo-p-dioxin (HpCDD)	250	---	4.50E-08	B
1,2,3,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	500	---	4.50E-08	B
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	50	---	4.50E-08	B
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	250	---	4.50E-08	B
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	250	---	4.50E-08	B
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	250	---	4.50E-08	B
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	250	---	4.50E-08	B
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	250	---	4.50E-08	B
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	250	---	4.50E-08	B
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	250	---	4.50E-08	B
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	250	---	4.50E-08	B
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	500	---	4.50E-08	B

Notes:
DQL indicates data quality limit.
PQL indicates laboratory practical quantitation limits.
MDL indicates laboratory detection limits.
--- indicates detection limit not provided.
B - Region IX PRG, based on carcinogenic effects.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6A. *Laboratory control limits for metals, mercury, cyanide, TOC, TPH, hardness, fluoride, total phosphorus, and orthophosphate for aqueous samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Aluminum	75-125	0-20
Antimony	75-125	0-20
Arsenic	75-125	0-20
Barium	75-125	0-20
Beryllium	75-125	0-20
Cadmium	75-125	0-20
Calcium	75-125	0-20
Chromium	75-125	0-20
Cobalt	75-125	0-20
Copper	80-120	0-20
Copper (furnace)	---	---
Iron	75-125	0-20
Lead	75-125	0-20
Magnesium	75-125	0-20
Manganese	75-125	0-20
Mercury	80-120	0-20
Nickel	75-125	0-20
Potassium	75-125	0-20
Selenium	75-125	0-20
Silver	75-125	0-20
Sodium	75-125	0-20
Thallium	75-125	0-20
Vanadium	75-125	0-20
Zinc	75-125	0-20
Zinc (furnace)	---	---
Cyanide	90-110	0-20
TOC	80-120	0-25
Hardness	---	---
TPH	30-139	0-40
Residue, dissolved	80-120	0-25
Residue, suspended	80-120	0-25
Fluoride	90-110	0-30
Total phosphorus	60-140	0-40

Table 6A. *Laboratory control limits for metals, mercury, cyanide, TOC, TPH, hardness, fluoride, total phosphorus, and orthophosphate for aqueous samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Orthophosphate	90-110	0-30

Notes:
RPD indicates relative percent difference.
--- indicates not provided:
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6B. *Laboratory control limits for metals, mercury, cyanide, TOC, TPH for soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Aluminum	75-125	0-20
Antimony	75-125	0-20
Arsenic	75-125	0-20
Barium	75-125	0-20
Beryllium	75-125	0-20
Cadmium	75-125	0-20
Calcium	75-125	0-20
Chromium	75-125	0-20
Cobalt	75-125	0-20
Copper	80-120	0-20
Copper (furnace)	---	---
Iron	75-125	0-20
Lead	75-125	0-20
Magnesium	75-125	0-20
Manganese	75-125	0-20
Mercury	80-120	0-20
Nickel	75-125	0-20
Potassium	75-125	0-20
Selenium	75-125	0-20
Silver	75-125	0-20
Sodium	75-125	0-20
Thallium	75-125	0-20
Vanadium	75-125	0-20
Zinc	75-125	0-20
Zinc (furnace)	---	---
Cyanide	75-125	0-30
TOC	60-140	0-40
TPH	40-140	0-40

Table 6B. *Laboratory control limits for metals, mercury, cyanide, TOC, TPH for soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)

Notes:
RPD indicates relative percent difference.
--- indicates not provided
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6B. *Laboratory control limits for metals, mercury, cyanide, TOC, TPH for soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Fluoride	75-125	0-25
Total phosphorus	60-140	0-40
Orthophosphate	75-125	0-30

Table 6C. ***Laboratory control limits for volatile organics in aqueous samples.***

Parameter	Accuracy (% Rec)	Precision (%RPD)
1,1-Dichloroethane	51-140	0-47
1,1,2-Trichloroethane	63-133	0-21
1,2-Dichloroethane	65-131	0-23
1,1,1-Trichloroethane	69-120	0-27
1,1,2,2-Tetrachloroethane	67-133	0-22
1,2-Dichloroethene (total)	43-136	0-22
1,2-Dichloropropane	67-128	0-24
1,1-Dichloroethene	46-147	0-30
2-Butanone	42-167	0-31
2-Hexanone	48-155	0-36
4-Methyl-2-pentanone	50-150	0-42
Acetone	32-174	0-52
Benzene	62-135	0-37
Bromodichloromethane	65-125	0-28
Bromoform	52-148	0-31
Bromomethane	40-141	0-33
Carbon disulfide	28-152	0-23
Carbon tetrachloride	57-128	0-38
Chlorobenzene	72-127	0-22
Chloroethane	47-148	0-34
Chloroform	62-130	0-20
Chloromethane	34-145	0-44
Cis-1,3-dichloropropene	66-125	0-21
Dibromochloromethane	68-126	0-31
Ethylbenzene	74-122	0-18
Methylene chloride	47-140	0-50
Styrene	66-130	0-28
Tetrachloroethene	60-148	0-24
Toluene	68-131	0-33
Trans-1,3-dichloropropene	49-136	0-24
Trichloroethene	56-143	0-35
Vinyl chloride	43-142	0-21
Xylenes (total)	73-135	0-26

Table 6C. *Laboratory control limits for volatile organics in aqueous samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)

Notes:
RPD indicates relative percent difference.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6D. *Laboratory control limits for volatile organics in soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
1,1-Dichloroethane	51-129	0-38
1,1,2-Trichloroethane	34-148	0-27
1,2-Dichloroethane	49-136	0-25
1,1,1-Trichloroethane	41-134	0-54
1,1,2,2-Tetrachloroethane	49-144	0-28
1,2-Dichloroethene (total)	37-142	0-56
1,2-Dichloropropane	52-124	0-27
1,1-Dichloroethene	40-164	0-46
2-Butanone	45-154	0-39
2-Hexanone	45-127	0-32
4-Methyl-2-pentanone	34-159	0-37
Acetone	43-154	0-28
Benzene	49-142	0-42
Bromodichloromethane	32-149	0-33
Bromoform	41-138	0-24
Bromomethane	23-173	0-79
Carbon disulfide	40-135	0-68
Carbon tetrachloride	40-135	0-59
Chlorobenzene	66-135	0-34
Chloroethane	30-135	0-51
Chloroform	50-133	0-38
Chloromethane	32-142	0-53
Bis-1,3-dichloropropene	40-133	0-34
Dibromochloromethane	47-135	0-22
Ethylbenzene	51-135	0-44
Methylene chloride	44-142	0-32
Styrene	43-140	0-45
Tetrachloroethene	71-146	0-44
Toluene	38-158	0-32
Trans-1,3-dichloropropene	45-131	0-50
Trichloroethene	51-146	0-34
Vinyl chloride	33-142	0-65
Xylenes (total)	37-133	0-43

Table 6D. *Laboratory control limits for volatile organics in soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)

Notes:
RPD indicates relative percent difference.
Source: Savannah Laboratories & Environemntal Services, Inc.

Table 6E. *Laboratory control limits for semivolatile organics in aqueous samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
1,2,4-Trichlorobenzene	28-110	0-28
1,2-Dichlorobenzene	34-130	0-30
1,3-Dichlorobenzene	28-130	0-26
1,4-Dichlorobenzene	27-130	0-31
2,4,5-Trichlorophenol	38-127	0-28
2,4,6-Trichlorophenol	36-126	0-22
2,2-Oxybis (1-chloropropane) {bis(2-chloroisopropyl)ether}	15-144	0-23
2,4-Dichlorophenol	25-134	0-30
2,4-Dinitrotoluene	37-129	0-32
2,6-Dinitrotoluene	24-139	0-24
2,4-Dinitrophenol	10-209	0-63
2-Chloronaphthalene	45-107	0-22
2-Chlorophenol	38-115	0-34
2-Methylnaphthalene	43-130	0-30
2-Methylphenol (o-cresol)	31-119	0-33
2-Nitroaniline	26-130	0-49
2-Nitrophenol	35-125	0-24
3,3-Dichlorobenzidine	10-144	0-72
3-Nitroaniline	10-130	0-57
4,6-Dinitro-2-methylphenol	10-173	0-33
4-Bromophenyl phenyl ether	36-124	0-26
4-Chloro-3-methyl-phenol	34-126	0-31
4-Chloroaniline	10-130	0-67
4-Chlorophenylphenyl ether	22-140	0-26
4-Methylphenol (p-cresol)	24-136	0-27
4-Nitroaniline	10-140	0-39
4-Nitrophenol	12-143	0-44
Acenaphthene	36-121	0-35
Acenaphthylene	41-121	0-28
Anthracene	45-126	0-21
Benzo(a)anthracene	33-136	0-34
Benzo(a)pyrene	45-120	0-24
Benzo(b)fluoranthene	33-132	0-32

Table 6E. *Laboratory control limits for semivolatile organics in aqueous samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Benzo(g,h,i)perylene	28-146	0-39
Benzo(k)fluoranthene	33-150	0-34
Bis(2-chloroethoxy) methane	47-110	0-20
Bis(2-ethylhexyl) phthalate	34-160	0-26
Bis(2-chloroethyl ether)	34-114	0-58
Butyl benzyl phthalate	38-141	0-41
Carbazole	48-127	0-23
Chrysene	44-128	0-31
Di-n-butyl phthalate	43-145	0-29
Di-n-octylphthalate	24-152	0-33
Dibenz(a,h)anthracene	33-143	0-35
Dibenzofuran	50-119	0-20
Diethylphthalate	46-134	0-49
Dimethylphthalate	22-141	0-31
Fluoranthene	41-129	0-24
Fluorene	50-124	0-23
Hexachlorobenzene	49-121	0-31
Hexachlorobutadiene	27-130	0-30
Hexachlorocyclopentadiene	D-130	0-67
Hexachloroethane	26-130	0-35
Indeno(1,2,3-cd)pyrene	37-140	0-38
Isophorone	29-130	0-33
n-Nitroso-di-n-propylamine	31-138	0-30
n-Nitrosodiphenylamine	24-146	0-25
Naphthalene	41-130	0-33
Nitrobenzene	50-111	0-21
Pentachlorophenol	19-148	0-33
Phenanthrene	50-121	0-20
Phenol	33-122	0-36
Pyrene	31-139	0-42

Notes:
RPD indicates relative percent difference.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6F. *Laboratory control limits for semivolatile organics in soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
1,2,4-Trichlorobenzene	10-112	0-22
1,2-Dichlorobenzene	25-115	0-24
1,3-Dichlorobenzene	26-108	0-28
1,4-Dichlorobenzene	10-105	0-31
2,4,5-Trichlorophenol	25-130	0-36
2,4,6-Trichlorophenol	41-130	0-30
2,2-Oxybis (1-chloropropane) {bis(2-chloroisopropyl)ether}	10-135	0-28
2,4-Dichlorophenol	32-130	0-60
2,4-Dinitrotoluene	11-120	0-37
2,6-Dinitrotoluene	10-112	0-45
2,4-Dinitrophenol	10-125	0-84
2-Chloronaphthalene	39-107	0-47
2-Chlorophenol	15-111	0-38
2-Methylnaphthalene	30-133	0-63
2-Methylphenol (o-cresol)	33-108	0-53
2-Nitroaniline	17-130	0-48
2-Nitrophenol	30-130	0-50
3,3-Dichlorobenzidine	10-115	0-39
3-Nitroaniline	14-130	0-28
4,6-Dinitro-2-methylphenol	10-117	0-57
4-Bromophenyl phenyl ether	31-157	0-19
4-Chloro-3-methyl-phenol	24-114	0-32
4-Chloroaniline	10-130	0-85
4-Chlorophenylphenyl ether	36-149	0-62
4-Methylphenol (p-cresol)	24-114	0-42
4-Nitroaniline	10-130	0-55
4-Nitrophenol	15-118	0-57
Acenaphthene	18-123	0-49
Acenaphthylene	42-119	0-48
Anthracene	40-148	0-27
Benzo(a)anthracene	54-137	0-43
Benzo(a)pyrene	41-142	0-55
Benzo(b)fluoranthene	43-134	0-51
Benzo(g,h,i)perylene	10-148	0-50

Table 6F. *Laboratory control limits for semivolatile organics in soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Benzo(k)fluoranthene	25-182	0-48
Bis(2-chloroethoxy) methane	34-108	0-52
Bis(2-ethylhexyl) phthalate	47-143	0-22
Bis(2-chloroethyl ether)	18-122	0-50
Butyl benzyl phthalate	58-122	0-27
Carbazole	10-158	0-50
Chrysene	56-133	0-41
Di-n-butyl phthalate	42-161	0-59
Di-n-octylphthalate	22-181	0-43
Dibenz(a,h)anthracene	31-129	0-24
Dibenzofuran	36-132	0-42
Diethylphthalate	31-130	0-40
Dimethylphthalate	49-130	0-45
Fluoranthene	39-157	0-50
Fluorene	27-151	0-50
Hexachlorobenzene	19-155	0-33
Hexachlorobutadiene	33-114	0-55
Hexachlorocyclopentadiene	D-132	0-50
Hexachloroethane	10-109	0-30
Indeno(1,2,3-cd)pyrene	24-136	0-28
Isophorone	15-115	0-50
N-nitroso-di-n-propylamine	11-122	0-37
n-Nitrosodiphenylamine	51-132	0-44
Naphthalene	25-131	0-34
Nitrobenzene	19-120	0-30
Pentachlorophenol	10-140	0-55
Phenanthrene	39-152	0-30
Phenol	13-115	0-39
Pyrene	10-133	0-42

Notes:
RPD indicates relative percent difference.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6G. *Laboratory control limits for pesticides, herbicides and PCBs in aqueous samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Aldrin	38-129	0-25
Alpha-BHC	46-131	0-30
Beta-BHC	36-153	0-35
Delta-BHC	53-137	0-41
Gamma-BHC (lindane)	40-139	0-26
Alpha-chlordane	55-125	0-17
Gamma-chlordane	54-128	0-18
4,4-DDD	32-155	0-39
4,4-DDE	48-145	0-18
4,4-DDT	50-147	0-27
Dieldrin	34-150	0-42
Endosulfan I	34-161	0-24
Endosulfan II	40-162	0-22
Endosulfan sulfate	28-156	0-28
Endrin	41-158	0-25
Endrin aldehyde	20-146	0-34
Endrin ketone	42-122	0-25
Heptachlor epoxide	43-141	0-31
Heptachlor	37-148	0-26
Methoxychlor	60-155	0-43
Toxaphene	12-130	0-30
PCB-1016	45-134	0-34
PCB-1221	20-173	0-110
PCB-1232	10-228	0-86
PCB-1242	37-160	0-74
PCB-1248	50-113	0-30
PCB-1254	50-122	0-39
PCB-1260	41-144	0-34
Monochlorobiphenyls	30-130	0-50
Dichlorobiphenyls	30-130	0-50
Trichlorobiphenyls	30-130	0-50
Tetrachlorobiphenyls	40-140	0-50
Pentachlorobiphenyls	40-140	0-50
Hexachlorobiphenyls	40-140	0-50

Table 6G. *Laboratory control limits for pesticides, herbicides and PCBs in aqueous samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Heptachlorobiphenyls	40-140	0-50
Octachlorobiphenyls	40-140	0-50
Nonachlorobiphenyls	30-130	0-50
Decachlorobiphenyls	30-130	0-50
2,4-D	11-154	0-78
2,4-DB	55-167	0-43
2,4,5-TP (silvex)	10-100	0-66
2,4,5-T	25-128	0-48
Dalapon	26-97	0-68
Dicamba	38-152	0-46
Dichlorprop	27-209	0-95
Dinoseb	10-127	0-115
MCPA	20-150	0-28
MCPP	10-164	0-78
4-Nitrophenol	---	---
Pentachlorophenol	11-110	0-34

Notes:
--- indicates not provided
RPD indicates relative percent difference.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6H. *Laboratory control limits for pesticides, herbicides and PCBs in soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Aldrin	10-144	0-38
Alpha-BHC	22-101	0-40
Beta-BHC	12-120	0-40
Delta-BHC	10-142	0-47
Gamma-BHC (lindane)	12-138	0-37
Alpha-chlordane	45-140	0-40
Gamma-chlordane	11-141	0-40
4,4-DDD	28-134	0-50
4,4-DDE	34-121	0-25
4,4-DDT	29-134	0-26
Dieldrin	28-137	0-30
Endosulfan I	10-141	0-40
Endosulfan II	10-159	0-65
Endosulfan sulfate	26-144	0-50
Endrin	33-149	0-32
Endrin aldehyde	10-130	0-86
Endrin ketone	29-112	0-31
Heptachlor epoxide	15-142	0-40
Heptachlor	17-138	0-38
Methoxychlor	24-152	0-40
Toxaphene	41-126	0-50
PCB-1016	34-138	0-44
PCB-1221	15-178	0-30
PCB-1232	10-215	0-30
PCB-1242	39-150	0-30
PCB-1248	38-158	0-30
PCB-1254	40-122	0-30
PCB-1260	39-138	0-30
Monochlorobiphenyls	30-130	0-50
Dichlorobiphenyls	30-130	0-50
Trichlorobiphenyls	30-130	0-50
Tetrachlorobiphenyls	40-140	0-50
Pentachlorobiphenyls	40-140	0-50
Hexachlorobiphenyls	40-140	0-50

Table 6H. *Laboratory control limits for pesticides, herbicides and PCBs in soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Heptachlorobiphenyls	40-140	0-50
Octachlorobiphenyls	40-140	0-50
Nonachlorobiphenyls	30-130	0-50
Decachlorobiphenyls	30-130	0-50
2,4-D	19-153	0-47
2,4-DB	20-160	0-40
2,4,5-TP (silvex)	27-120	0-51
2,4,5-T	14-143	0-59
Dalapon	10-170	0-40
Dicamba	20-160	0-40
Dichlorprop	30-170	0-40
Dinoseb	30-170	0-40
MCPA	30-170	0-40
MCPP	30-170	0-40
4-Nitrophenol	---	---
Pentachlorophenol	10-150	0-40

Notes:
--- indicates not provided
RPD indicates relative percent difference.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6I. *Laboratory control limits for dioxins (method 8280A) in aqueous and soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	50-150	±50
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	50-150	±50
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	50-150	±50
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	50-150	±50
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	50-150	±50
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	50-150	±50
1,2,3,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	50-150	±50
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	50-150	±50
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	50-150	±50
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	50-150	±50
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	50-150	±50
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	50-150	±50
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	50-150	±50
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	50-150	±50
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	50-150	±50
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	50-150	±50
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	50-150	±50

Notes:
RPD indicates relative percent difference.
Source: Triangle Laboratories, Inc.

Table 6J. *Laboratory control limits for dioxins (method 8290) in aqueous and soil samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	70-130	±20
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	70-130	±20
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	70-130	±20
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	70-130	±20
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	70-130	±20
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	70-130	±20
1,2,3,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	70-130	±20
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	70-130	±20
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	70-130	±20
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	70-130	±20
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	70-130	±20
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	70-130	±20
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	70-130	±20
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	70-130	±20
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	70-130	±20
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	70-130	±20
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	70-130	±20

Notes:
RPD indicates relative percent difference.
Source: Triangle Laboratories, Inc.

Table 6K. ***Laboratory control limits for semivolatiles in air samples.***

Parameter	Accuracy (% Rec)	Precision (%RPD)
Acenaphthene	67-112	0-25
Acenaphthylene	60-102	0-25
Anthracene	70-130	0-25
Benzo(a)anthracene	73-101	0-25
Benzo(b)fluoranthene	70-130	0-25
Benzo(k)fluoranthene	70-130	0-25
Benzo(a)pyrene	74-104	0-25
Benzo(g,h,i)perylene	48-100	0-25
Benzyl alcohol	58-100	0-25
Bis(2-chloroethoxy)methane	66-100	0-25
Bis(2-chloroethyl)ether	50-100	0-25
Bis(2-chloroisopropyl)ether	62-100	0-25
Bis(2-ethylhexyl)phthalate	50-150	0-25
4-Bromophenyl phenyl ether	70-130	0-25
Butylbenzyl phthalate	50-150	0-25
4-Chloroaniline	62-100	0-25
4-Chloro-3-methyl phenol	70-130	0-25
2-Chloronapthalene	69-100	0-25
2-Chlorophenol	53-100	0-25
4-Chlorophenyl phenyl ether	50-150	0-25
Chrysene	70-130	0-25
Dibenz(a,h)anthracene	55-100	0-25
Dibenzofuran	74-122	0-25
1,2-Dichlorobenzene	46-100	0-25
1,3-Dichlorobenzene	41-100	0-25
1,4-Dichlorobenzene	44-100	0-25
3,3'-Dichlorobenzidine	77-136	0-25
2,4-Dichlorophenol	69-100	0-25
Diethylphthalate	70-130	0-25
2,4-Dimethylphenol	48-100	0-25
Dimethylphthalate	70-130	0-25
Di-n-butylphthalate	50-150	0-25
2,4-Dinitrotoluene	66-110	0-25
2,6-Dinitrotoluene	59-100	0-25
Di-n-octyl phthalate	50-150	0-25
Fluoranthene	70-130	0-25
Fluorene	70-130	0-25
Hexachlorobenzene	74-123	0-25
Hexachlorobutadiene	58-104	0-25
Hexachloroethane	44-100	0-25
Indeno(1,2,3-cd)pyrene	59-100	0-25
Isophorone	52-100	0-25
2-Methyl naphthalene	24-107	0-25
2-Methylphenol	59-100	0-25
4-Methylphenol	59-109	0-25
Naphthalene	30-100	0-25

Table 6K. ***Laboratory control limits for semivolatiles in air samples.***

Parameter	Accuracy (% Rec)	Precision (%RPD)
2-Nitroaniline	62-100	0-25
3-Nitroaniline	75-100	0-25
4-Nitroaniline	76-100	0-25
Nitrobenzene	20-100	0-25
2-Nitrophenol	35-100	0-25
n-Nitrosodiphenylamine	70-130	0-25
n-Nitrosodi-n-propylamine	63-100	0-25
Phenanthrene	70-130	0-25
Phenol	74-135	0-25
Pyrene	70-130	0-25
1,2,4-Trichlorobenzene	57-100	0-25
2,4,5-Trichlorophenol	77-121	0-25
2,4,6-Trichlorophenol	65-105	0-25

Notes:
RPD indicates relative percent difference.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6L *Laboratory control limits for volatiles in air samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Dichlorodifluoromethane	60-140	0-40
Chloromethane	60-140	0-40
Vinyl chloride	60-140	0-40
Bromomethane	60-140	0-40
Chloroethane	60-140	0-40
Trichlorofluoromethane	60-140	0-40
1,1-Dichloroethene	60-140	0-40
Methylene chloride (dichloromethane)	60-140	0-40
Trans-1,2-dichloroethene	60-140	0-40
1,1-Dichloroethane	60-140	0-40
2,2-Dichloropropane	60-140	0-40
Cis-1,2-dichloroethene	60-140	0-40
Chloroform	60-140	0-40
Bromochloroemthane	60-140	0-40
1,1,1-Trichloroethane	60-140	0-40
1,1-Dichloropropylene	60-140	0-40
Carbon tetrachloride	60-140	0-40
1,2-Dichloroethane	60-140	0-40
Benzene	60-140	0-40
Trichloroethylene	60-140	0-40
1,2-Dichloropropane	60-140	0-40
Bromodichloromethane	60-140	0-40
Dibromomethane	60-140	0-40
Trans-1,3-dichloropropene	60-140	0-40
Toluene	60-140	0-40
Cis-1,3-dichloropropene	60-140	0-40
1,1,2-Trichloroethane	60-140	0-40
1,3-Dichloropropane	60-140	0-40
Tetrachloroethene	60-140	0-40
Dibromochloromethane	60-140	0-40
1,2-Dibromomethane	60-140	0-40
Chlorobenzene	60-140	0-40
1,1,1,2-Tetrachloroethane	60-140	0-40
Ethylbenzene	60-140	0-40
M&p-Xylene	60-140	0-40

Table 6L *Laboratory control limits for volatiles in air samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
o-Xylene	60-140	0-40
Styrene	60-140	0-40
Isopropylbenzene	60-140	0-40
Bromoform	60-140	0-40
1,1,2,2-Tetrachloroethane	60-140	0-40
1,2,3-Trichloropropane	60-140	0-40
n-Propylbenzene	60-140	0-40
Bromobenzene	60-140	0-40
1,3,5-Trimethylbenzene	60-140	0-40
2-Chlorotoluene	60-140	0-40
4-Chlorotoluene	60-140	0-40
t-Butylbenzene	60-140	0-40
1,2,4-Trimethylbenzene	60-140	0-40
s-Butylbenzene	60-140	0-40
p-Isopropyltoluene	60-140	0-40
1,3-Dichlorobenzene	60-140	0-40
1,4-Dichlorobenzene	60-140	0-40
n-Butylbenzene	60-140	0-40
1,2-Dichlorobenzene	60-140	0-40
1,2-Dibromo-3-chloropropane	60-140	0-40
1,2,4-Trichlorobenzene	60-140	0-40
Hexachlorobutadiene	60-140	0-40
Naphthalene	60-140	0-40
1,2,3-Trichlorobenzene	60-140	0-40
Acetone	60-140	0-40
2-Butanone (MEK)	60-140	0-40
Vinyl acetate	60-140	0-40
4-Methyl-2-pentanone (MIBK)	60-140	0-40
2-Hexanone	60-140	0-40
Carbon disulfide	60-140	0-40

Notes:
RPD indicates relative percent difference.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6M. *Laboratory control limits for PCBs in air samples*

Parameter	Accuracy (% Rec)	Precision (% RPD)
PCB-1016	34-137	0-44
PCB-1221	15-178	0-30
PCB-1232	10-215	0-30
PCB-1242	39-150	0-30
PCB-1248	38-158	0-30
PCB-1254	66-122	0-30
PCB-1260	58-150	0-30

Notes:
RPD indicates relative percent difference.
Source: Savannah Laboratories & Environmental Services, Inc.

Table 6N. *Laboratory control limits for dioxins in air samples.*

Parameter	Accuracy (% Rec)	Precision (%RPD)
Internal Standards		
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	40-130	0-20
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	40-130	0-20
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	40-130	0-20
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	40-130	0-20
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	40-130	0-20
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	40-130	0-20
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	25-130	0-20
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	25-130	0-20
1,2,3,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	25-130	0-20
Surrogate Standards		
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	40-130	0-20
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	40-130	0-20
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	40-130	0-20
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	40-130	0-20
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	25-130	0-20
Alternate Standards		
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	40-130	0-20
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	40-130	0-20

Notes:
RPD indicates relative percent difference.
Lab control spile/lab control spike dup - 70%-130%
Exceptions:
Up to 2 analytes may have recoveries between 60-145% if the associated RPDs are met.
Up to 2 analytes may have RPDs up to 35% if the associated % recoveries are met.
Source: Triangle Laboratories, Inc.

Table 7A. *Volatile organic compounds using USEPA Method 8260B Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Holding times	Samples must be extracted and analyzed within holding time.	VOCs: Analyze within 14 days from collection.	If holding times are exceeded for initial or any reanalyses required due to QC excursions, notify QAO* immediately since resampling may be required. Document corrective action in the case narrative.
MS Tuning	Once every 12 hours prior to initial calibration and calibration verifications.	1. BFB key ions and abundance criteria listed in the method must be met for all 9 ions and analyses must be performed within 12 hours of injection of the BFB. 2. Part of the BFB peak will not be background subtracted to meet tune criteria. 3. Documentation of all BFB analyses and evaluation must be included in the data packages.	1. Tune the mass spectrometer. 2. Document corrective action in the case narrative - **samples cannot be analyzed until control limit criteria have been met.**
Initial Calibration	Prior to sample analysis and when calibration verifications criteria are not met. Initial calibration will contain all target analytes in each standard.	1. Five concentrations bracketing expected concentration range for all compounds of interest; one std must be near the PQL. 2. CCC compounds $\leq$30% RSD, remaining compounds $\leq$50% RSD. 3. SPCC RF as listed in method, non-SPCC $\geq$ 0.050 RF except for ketones and 2-chloroethyl vinyl ether with RF $\geq$ 0.010. 4. For compound with %RSD >15, quantitation must be performed using a separate calibration curve and the COD must be $>$ 0.99.	1. Identify and correct problem. 2. If criteria are still not met, recalibrate. 3. Document corrective action in the case narrative - **samples cannot be analyzed until calibration control limit criteria are met. Contact QAO* to discuss problem target analytes such as 2-chloroethyl vinyl ether before proceeding with analysis.**

Table 7A. *Volatile organic compounds using USEPA Method 8260B Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Calibration Verification	Every 12 hours, following BFB. The calibration verification will contain all target analytes in each standard at a concentration that is representative of the midpoint of the initial calibration.	1. Within method specified criteria, and percent drift or percent difference (%D) ≤ 20 for CCC compounds, ≤ 50% D for remaining compounds, SPCC RF same as listed in initial calibration. 2. The internal standards areas and retention times must meet the method criteria.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate and notify QAO*. 3. Document corrective action in the case narrative - **samples cannot be analyzed until calibration control limit criteria are met.** **If the laboratory chooses to apply the grand mean exception (average % drift or % difference is less than 15%), the QAO* will be contacted prior to proceeding with analysis.**
Preparatio n Blank Analysis	Every 12 hours, following calibration verification	Common laboratory contaminants (methylene chloride, acetone) less than 3 X PQL; anything else less than PQL. PQLs will be provided along with the preparation blank results.	1. Reanalyze blank. 2. If limits are still exceeded, contact QAO*, clean instrument, recalibrate analytical system, and reanalyze all samples if detected for same compounds as in blank. 3. Document corrective action in the case narrative - **samples cannot be analyzed until blank criteria have been met.**
Field / Equipment Blank Analysis	Collected one per sampling equipment and after every 10 samples.	Common laboratory contaminants less than 3 X PQL; anything else less than PQL.	1. Investigate problem, contact QAO*. 2. Write an explanation in the case narrative.
Trip Blank	1 per cooler containing VOC samples.	Common laboratory contaminants less than 3 X PQL; anything else less than PQL.	1. Investigate problem, contact QAO*. 2. Write an explanation in the case narrative.
Laboratory Control Sample Analysis	Each analytical batch (every 12 hours). Prepared independently from calibration standards. Spike must contain all target analyte and should be at a concentration which is in the lower 1/2 of the calibration curve.	Recovery within laboratory control limits.. For compounds without established laboratory control limits, 50 to 150% recovery will be used.	1. If recovery failures are above control limits and these compounds are not detected in the associated samples, contact QAO*. 2. If recovery failures are below control limits, reanalyze LCS and examine results of other QC analyses. 3. If recovery is still outside limits, and other QC criteria are met, contact QAO*. 4. If other QC criteria have not been met, stop analysis, locate and correct problem, recalibrate instrument and reanalyze samples since last satisfactory LCS. 5. Document corrective action in the case narrative.

Table 7A. *Volatile organic compounds using USEPA Method 8260B Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Internal Standards	All samples and blanks (including MS/MSD)	1. Response -50% - +100% of internal standards from continuing calibration of the day. 2. RT must be ± 30 sec. from associated calibration verification standard of that sequence.	1. Reanalyze. 2. If still outside of the limits, report both analyses, and contact the QAO*. 3. Document corrective action in the case narrative. Special Circumstances: If matrix interferences is present (as demonstrated by the lab and documented in the case narrative): 1. Reanalyze (may be at a higher dilution) 2. If internal standard is >10%, report both runs. 3. If internal standard is <10%, report both runs and contact QAO*.
Surrogate Spike	All samples and blanks (including MS/MSD)	Recovery within laboratory control limits.	1. Reanalyze any environmental or QC sample with surrogates that exceed control limits. 2. If still outside of the limits, report both analyses and contact the QAO*. 3. Document corrective action in the case narrative. Special Circumstances: If matrix interference is present (as demonstrated by the lab and documented in the case narrative): 1. Reanalyze (may be at a higher dilution) 2. If surrogate recovery is >10%, report both runs. 3. If surrogate recovery is <10%, report both runs and contact QAO*.
Matrix Spike/ Matrix Spike Dup. (MS/MSD) Analysis	1 per group of similar concentration and matrix, 1 per case of samples, or 1 in 20, whichever is greater.	Recovery and RPD within laboratory control limits. Spike must contain target analytes.	1. Reanalyze if <10%. 2. If reanalysis is still <10%, report both analyses and document in the case narrative. 2. If >10% and LCS criteria are met, document in case narrative; no additional corrective action required. 3. If LCS criteria are exceeded also, examine other QC data for source of problem; *i.e.*, surrogate recoveries for extraction efficiency and calibration data for instrument performance issues, and contact QAO*. Re-extract or reanalyze samples and associated MS/MSD and LCSs as required.
Field Dup. Analysis	Collected 1 per matrix; every 10 samples of similar matrix	50% RPD for waters and 100% RPD for soil.	If these criteria are not met, sample results will be evaluated on a case by case basis.

Table 7A. *Volatile organic compounds using USEPA Method 8260B Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Tentatively Identified Compound	If required, perform for each sample and blank analysis. Non-target compounds will be reported using a Mass Spectral Library search.	not applicable	not applicable
Dilutions	1. When target analyte concentration exceeds upper limit of calibration curve. 2. When matrix interference is demonstrated by the lab and documented in the case narrative (highly viscous samples or a large number of nontarget peaks on the chromatogram). The QAO* will be contacted. 3. A reagent blank will be analyzed if an analyte saturates the detector or if highly concentrated analytes are detected. 4. Laboratory will note in the data deliverables which analytical runs were reported.	1. The reagent blank will meet the method blank criteria.	1. Reanalyze reagent blank until method blank criteria are met.
Laboratory control limits	1. Generated with results for an analyte from a minimum of 20 sample analyses. The average of the sample results and the standard deviation are calculated. The internal warning limits are established at 2 times the standard deviation and the control limits are established at 3 times the standard deviation. The control limits are updated annually.	not applicable	not applicable

Table 7A. *Volatile organic compounds using USEPA Method 8260B Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Percent solids	For soil samples, the percent solids will be determined and sample results will be corrected for percent solids.	not applicable	not applicable

Notes:
*indicates that d ata validation will be performed in accordance with QA/QC criteria established in these tables and the analytical methods. Excursions from QA/QC criteria will be qualified based on guidance provided in Section 9.2.2 of this QAPP.
QAO* indicates that communications with the QAO will be documented and included in the data packages.

Table 7B. *Semivolatile organic compounds using USEPA Method 8270C Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Holding Times	Samples must be extracted and analyzed within holding time.	SVOCs: Extract within 7 days for aqueous and 14 days for soil samples from collection. Analyze extracts within 40 days of extraction.	If holding times are exceeded for initial or any reanalyses required due to QC excursions, notify the QAO* immediately since resampling may be required.
MS Tuning	Once every 12 hours prior to initial calibration and calibration verification.	1. DFTPP key ions and abundance criteria listed in the method must be met for all 13 ions and analyses must be performed within 12 hours of injection of the DFTPP. 2. Part of the DFTPP peak will not be background subtracted to meet tune criteria. 3. Documentation of all DFTPP analyses and evaluations must be included in the data packages.	1. Tune the mass spectrometer. 2. Document corrective action in the case narrative - **samples cannot be analyzed until control limit criteria have been met.**
Initial Calibration	Prior to sample analysis and when calibration verification criteria are not met. Initial calibration will contain all target analytes in each standard.	1. Five concentrations bracketing expected concentration range for all compounds of interest; one standard must be near the PQL. 2. CCC compounds meet method RSD, remaining compounds ≤ 50% RSD. 3. SPCC RF as listed in method, non-SPCC ≥ 0.050 RF. 4. For compounds with %RSD >15, quantification must be performed using a separate calibration curve and the COD must be ≥ 0.99.	1. Identify and correct problem. 2. If criteria are still not met, recalibrate. 3. Document corrective action in the case narrative - **samples cannot be analyzed until calibration control limit criteria are met.** **Contact QAO* to discuss problem target analytes such as benzoic acid and kepone before proceeding with analysis.**
Calibration Verification	Every 12 hours, following DFTPP. Calibration verification will contain all target analytes in each standard at a concentration that is representative of the midpoint of the initial calibration.	1. Within method specified criteria, percent drift or percent difference (%D) ≤ 20 for CCC compounds and ≤ 50 %D for remaining compounds, SPCC RF as listed in method, non-SPCC ≥ 0.050. 2. The internal standards areas and retention times must meet the method criteria.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate and notify QAO*. 3. Document corrective action in the case narrative - **samples cannot be analyzed until calibration control limit criteria are met.** **If the laboratory chooses to apply the grand mean exception (average % drift or % difference is less than 15%), the QAO* will be contacted prior to proceeding with analysis.**

Table 7B. *Semivolatile organic compounds using USEPA Method 8270C Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Preparation Blank Analysis	Prepared with each extraction batch of no more than 20 analytical samples.	1. Common laboratory contaminants (phthalate) less than 3 X PQL, anything else less than PQL. 2. PQLs will be provided along with the preparation blank results.	1. Reanalyze blank. 2. If limits are still exceeded, clean instrument, recalibrate analytical system and reextract and reanalyze all samples if detected for same compounds as in the blank. 3. Document corrective action in the case narrative - **samples cannot be analyzed until blank criteria have been met.**
Field / Equipment Blank Analysis	Collected one per sampling equipment and after every 10 samples.	Common laboratory contaminants less than 3 X PQL; anything else less than PQL.	1. Investigate problem, contact QAO*. 2. Write an explanation in the case narrative.
Laboratory Control Sample Analysis	Prepared with each extraction batch, of no more than 20 analytical samples. Prepared independently from calibration standards. Spike must contain all target compounds and should be at a concentration which is approximately in the lower 1/2 of the calibration curve.	Recovery within laboratory control limits. For compounds without established laboratory control limits, 50 to 150% recovery will be used.	1. If recovery failures are above control limits and these compounds are not detected in the associated samples, contact QAO*. 2. If recovery failures are below the control limits, reanalyze LCS and examine results of other QC analyses. 3. If recovery is still outside limits, and other QC criteria are met, contact QAO*. 4. If other QC criteria have not been met, stop analysis, locate and correct problem, recalibrate instrument and reanalyze samples since last satisfactory LCS. 5. Document corrective action in the case narrative.
Internal Standards	All samples and blanks (including MS/MSD).	1. Response -50% - +100% of the internal standards from the continuing cal of the day. 2. RT must be ± 30 sec. from calibration verification of that sequence.	1. Reanalyze. 2. If recovery is still outside criteria, report both analyses, and contact the QAO*. 3. Document corrective action in the case narrative. Special Circumstances: If matrix interferences is present (as demonstrated by the lab and documented in the case narrative): 1. Reanalyze (may be at a higher dilution) 2. If internal standard is >10%, report both runs 3. If internal standard is <10%, report both runs and contact the QAO*.

Table 7B. *Semivolatile organic compounds using USEPA Method 8270C Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Surrogate Spike	All samples and blanks (including MS/MSD).	Recovery within laboratory control limits.	1. Reanalyze if more than 1 AE or 1 BN fails, or if any one surrogate %R is < 10%. 2. If recovery is still outside control limits and if the recovery is < 10%, reextract if still in holding time. 3. If recovery is still outside control limits, and if recovery is >10%, report both analyses. 3. Document corrective action in the case narrative. Special Circumstances: If matrix interference is present (as demonstrated by the lab and documented in the case narrative): 1. Reanalyze (may be at a higher dilution) 2. If surrogate recovery is >10%, report both runs. 3. If surrogate recovery is <10%, report both runs and contact QAO*.
Matrix Spike/ Matrix Spike Dup. (MS/MSD) Analysis	1 per group of similar concentration and matrix, 1 per case of samples, or 1 in 20, whichever is greater. Spike must contain target analytes.	Recovery and RPD within laboratory control limits.	1. Reanalyze if <10%. 2. If reanalysis is still < 10%, report both analyses and document in the case narrative. 3. If >10%, and LCS criteria are met, document in the case narrative. 4. If LCS criteria are exceeded also, examine other QC data for source of problem; ie surrogate recoveries for extraction efficiency and calibration data for instrument performance issues and contact QAO* and re-extract or reanalyze samples and associated MS/MSD and LCSs as required.
Field Dup. Analysis	Collected 1 per matrix; every 10 samples of similar matrix.	50% RPD for waters and 100% RPD for soil.	If these criteria are not met, sample results will be evaluated on a case by case basis.
Tentatively Identified Compounds	If required , for each sample and blank analysis. Non-target compounds will be reported using a Mass Spectral Library search.	not applicable	not applicable

Table 7B. *Semivolatile organic compounds using USEPA Method 8270C Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Dilutions	1. When target analyte concentration exceed upper limit of calibration curve. 2. When matrix interference demonstrated by lab and documented in the case narrative (highly viscous samples or a large number of nontarget peaks on the chromatogram). The QAO* will be contacted. 3. Samples should be cleaned up during sample preparation/extraction procedure using appropriate methods when matrix interference is present. 4. Laboratory will note in the data deliverables which analytical runs were reported.	1. The reagent blank will meet the method blank criteria.	1. Reanalyze reagent blank until method blank criteria are met.
Laboratory control limits	1. Generated with results for an analyte from a minimum of 20 sample analyses. The average of the sample results and the standard deviation are calculated. The internal warning limits are established at 2 times the standard deviation and the control limits are established at 3 times the standard deviation. The control limits are updated annually.	not applicable	not applicable
Percent solids	For soil samples, the percent solids will be determined and sample results will be corrected for percent solids.	not applicable	not applicable

Table 7B. *Semivolatile organic compounds using USEPA Method 8270C Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Notes: *indicates that data validation will be performed in accordance with QA/QC criteria established in these tables and the analytical methods. Excursions from QA/QC criteria will be qualified based on guidance provided in Section 9.2.2 of this QAPP. QAO* indicates that communications with the QAO will be documented and included in the data packages.			

Table 7C. *Pesticides SW-846 Method 8081A, Herbicides SW-846 Method 8151A, and TPH , as Diesel range organics (DRO) SW-846 Method 8015B Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Laboratory Corrective Action
Holding Times	Samples must be extracted and analyzed within holding time.	Extract within 7 days for aqueous and 14 days for soil samples from collection. Analyze extracts within 40 days.	If holding times are exceeded for initial or any reanalyses required due to QC excursions, notify the QAO immediately since resampling may be required.
Initial Calibration	Prior to start up and when criteria are exceeded for continuing calibration.	1. Minimally five concentrations, one calibration standard must be at concentration less than or equal to the PQL. 2. Toxaphene, technical chlordane require a single point calibration. If detected in samples, the samples are re-analyzed behind a five point calibration for each detected analyte. 32. If RSD <20% the average RRF may be used for quantitation. If RSD >20% a first or second order calibration curve with a correlation coefficient >0.99 must be used for quantitation.	1. Identify and correct problem. 2. Recalibrate instrument; samples must not be analyzed until initial calibration criteria are met.
Calibration Verification	Calibration standards must contain target compounds at mid-range concentration. Minimally, analyze calibration standards daily and every 12 hours. Calibration verification standards should be analyzed every 20 samples.	%D <15%.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate; reanalyze samples back to last compliant calibration standard. Samples must be bracketed by compliant calibration standards. **If the laboratory chooses to apply the grand mean exception (average % drift or % difference is less than 15%), the QAO* will be contacted prior to proceeding with analysis.**
Retention Time Windows	Retention time windows must be established in accordance with USEPA method 8000 or relative retention times must be used if internal standards are employed .	Compounds must be within established retention time windows or within laboratory established relative retention time criteria for the succeeding calibration standards.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate; reanalyze samples back to last compliant calibration standard.

Table 7C. *Pesticides SW-846 Method 8081A, Herbicides SW-846 Method 8151A, and TPH , as Diesel range organics (DRO) SW-846 Method 8015B Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Laboratory Corrective Action
Method Blank Analysis	1 per 20 samples of similar matrix extracted at the same time.	Compound concentrations must be <PQL .	1. Reanalyze. 2. If limits are still exceeded, re-extract and reanalyze method blank and associated samples if holding times have not elapsed. 3. If holding times have elapsed, contact the QAO immediately since resampling may be required.
LCS Analysis	1 per 20 samples of similar matrix extracted at the same times. LCSs must be spiked with target compounds (with the exception of toxaphene, chlordane) at concentration specified in the method.	Percent recoveries must be within laboratory control limits.	1. Reanalyze and examine results of other QC analyses. 2. If the percent recovery is above laboratory control limits (biased high) and the affected compound is not detected in the associated samples, corrective action is not required; document in case narrative. 3. If percent recovery is below laboratory control limits or <10%, reanalyze the LCS one additional time. If recoveries remain below limits and other QC criteria (surrogate, internal standards, calibration) have been met, notify QAO and document in case narrative report. 4. If recoveries are below laboratory control limits and additional QC excursions are observed, locate and correct problem, recalibrate instrument and re-extract and/or re-analyze samples since last satisfactory LCS. If samples requiring re-extraction or reanalysis over holding time requirements, notify the QAO immediately prior to proceeding since resampling may be required.
MS/MSD Analysis	1 per matrix type and every 20 samples of similar matrix. MS/MSDs must be spiked with target compounds (with the exception of toxaphene, chlordane) at concentrations specified in the method.	Recovery and RPD within laboratory control limits.	1. If LCS criteria are met, document in case narrative; no additional corrective action required. 2. If LCS criteria are exceeded also, examine other QC data for source of problem; ie surrogate recoveries for extraction efficiency and calibration data for instrument performance issues. 3. Take corrective action as required, re-extract or reanalyze samples and associated MS/MSD and LCSs as required.

Table 7C. *Pesticides SW-846 Method 8081A, Herbicides SW-846 Method 8151A, and TPH , as Diesel range organics (DRO) SW-846 Method 8015B Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Laboratory Corrective Action
Surrogate Spike	Samples, blanks, MS/MSDs, and LCSs must be spiked with method specified surrogate compounds.	1. Recovery within laboratory control limits. 2. Corrective action is not required if one of the two required surrogates has recovery outside of control limits if the recovery is >10%.	1. Reanalyze. 2. If recovery is still outside control limits but >10%, document in case narrative report. 3. If recovery is <10% with reanalysis, re-extract and reanalyze the sample if the holding time has not elapsed. If holding time has elapsed, notify the QAO immediately prior to proceeding since resampling may be required. Special Circumstances. If matrix interference is present (as demonstrated by the lab in the case narrative): 1. Reanalyze (may be at a higher dilution) 2. If surrogate recovery is >10%, Report Run. 3. If surrogate recovery is <10%, Contact QAO.
Identification	Samples, blanks, and QC data.	1. Retention times must be within established retention time windows or must meet relative retention time criteria. 2. Confirmation analysis is required.	1. Investigate problem; reanalyze calibration standards to check for retention time shift.
Quantitation	Samples, blanks, and QC data.	1. Internal and external standard method. Verify concentration is within linear calibration range. 2. For DROs, use the sum of the areas of peaks eluting between C10 and C28. 3. Every effort must be made to meet specified PQL requirements. Soil samples concentrations must be corrected to dry weight.	1. If concentration is above linear calibration range, dilute sample and reanalyze. Dilution should result in concentration in the upper calibration range of the instrument.
Field/ Equipment Blank Analysis	Collected one per sampling equipment and after every 10 samples.	Compounds concentrations must be <PQL.	1. Investigate problem; reanalyze to verify laboratory cross contamination is not a factor. 2. Notify the QAO immediately since resampling may be necessary.

Table 7C. *Pesticides SW-846 Method 8081A, Herbicides SW-846 Method 8151A, and TPH , as Diesel range organics (DRO) SW-846 Method 8015B Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Laboratory Corrective Action
Field Duplicate Analysis	Collected 1 per matrix type; every 10 samples of similar matrix.	50% RPD for waters and 100% RPD for soil.	No corrective action required of the laboratory since the laboratory will not know the identity of the field duplicate samples. If these criteria are not met, sample results will be evaluated on a case by case basis during the validation process.
Confirmation Analysis for pesticides, herbicides, TPH	Dual column quantitation confirmation will be performed at a 10% per matrix frequency. Qualitative confirmation will be performed for pesticide and herbicide sample results. If matrix interference is present, qualitative confirmation will be performed.	Not Applicable	Not Applicable

Note
*indicates that d ata validation will be performed in accordance with QA/QC criteria established in these tables and the analytical methods. Excursions from QA/QC criteria will be qualified based on guidance provided in Section 9.2.2 of this QAPP.
QAO* indicates that communications with the QAO will be documented and included in the data packages.

Table 7D. *PCBs Method 680 by Selected Ion Monitoring (SIM) Mode Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Laboratory Corrective Action
Holding Times	Samples must be extracted and analyzed within holding time.	Extract within 7 days for aqueous and 14 days for soil samples from collection. Analyze extracts within 40 days.	If holding times are exceeded for initial or any reanalyses required due to QC excursions, notify the QAO immediately since resampling may be required.
MS Tuning	At the beginning of the 12 hour sequence. Prior to calibration, blank, sample and QC sample analysis.	1. Tune instrument in accordance with method 680 2. Size of DFTPP peak should be within instrument specific established area window.	1. Identify and correct problem. 2. Re-tune the mass spectrometer; samples must not be analyzed until tuning criteria are met.
Initial Calibration	Prior to start up after tuning and when criteria are exceeded for continuing calibration.	1. Minimally five concentrations, one calibration standard must be at reporting limit. 2. Single PCB congener of each chlorination level is used for calibration and quantitation. Decachlorobiphenyl is ued to quantify nonachlorobiphenyls. 2. If RSD <20% for water, 30% for soil, the average RRF may be used for quantitation.	1. Identify and correct problem. 2. Recalibrate instrument; samples must not be analyzed until initial calibration criteria are met.
Calibration Verification	Calibration standards must contain target compounds at mid-range concentration. Minimally, analyze calibration standards prior to sample analysis and af the end of the sample sequence, and every 12 hours.	1. %D <20% for water, 30% for soil. 2. Mass abundance ratio of all calibration congeners within acceptable range. 3. Baseline separators of PCB congener #87 from #154 and #77. 4. Signal to noise ratio of ≥5 for decachlorobiphenyl ion # 499 and chrysene-d12 ion # 241. 5. Decachlorobiphenyl mass abundances for mass 500 ≥70% and ≤95% for mass 498.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate; reanalyze samples back to last compliant calibration standard. Samples must be bracketed by compliant calibration standards.

Table 7D. *PCBs Method 680 by Selected Ion Monitoring (SIM) Mode Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Laboratory Corrective Action
Window defining mixture	At the beginning of 12 hour sequence, prior to initial calibration or continuing calibration standard.	1. Must contain the first and last for each congener at each level of chlorination. 2. In accordance with Method 680 Section 10.3.3. Llaboratory SOP Table 3 must be met. 3. All peaks must be labeled and identified on the chromatograms, additionally, first eluters should be labeled with the letter F, and the last eluters with the letter L.	1. Identify and correct problems 2. Reanalyze; samples must not be analyzed until GC column performance check criteria are established.
Internal Standards	Samples, blanks, MS/MSDs, LCSs are spiked with chrysene-d10.	1. Percent recoveries must be within 30% of previous calibration verification and 50% of initial calibration. 2. Ion abundance criteria specified in SOP must be met. 3. Retention times should not be significantly changed during the sequence.	1. Re-extract and/or re-analyze. 2. If re-extraction and re-analysis does not solve problem and other QC criteria were met, submit both runs and discuss in narrative report.
Surrogates	Samples, blanks, and MS/MSDs are spiked with ^{13}C-Decachlorobiphenyl.	Percent recoveries must be within SOP criteria.	1. Re-extract and/or re-analyze. 2. If re-extraction and re-analysis does not solve problem and other QC criteria were met, submit both runs and discuss in narrative report
Method Blank Analysis	1 per 20 samples of similar matrix extracted at the same time, analyzed between the calibration standard and samples.	Compound concentrations must be <reporting limit.	1. Reanalyze. 2. If limits are still exceeded, re-extract and reanalyze method blank and associated samples if holding times have not elapsed. 3. If holding times have elapsed, contact QAO Manager since resampling may be required.
MS/MSD Analysis	1 per matrix type and every 20 samples of similar matrix. MS/MSDs must be spiked with one PCB congener of each chlorination level.	Recovery within criteria listed in Section 5 of the SOP.	1. Reanalyze. 2. If recovery or RPD is still outside limits, document in case narrative report.

Table 7D. *PCBs Method 680 by Selected Ion Monitoring (SIM) Mode Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Laboratory Corrective Action
Identification	Samples, blanks, and QC data.	1.The retention time must be within the corresponding retention time established by the window defining mixture for each chlorination level. 2. The ion current response for both ions must reach a maximum with ±1 scan. 3. Ion abundance rations specified in SOP must be met. 4. The area of the ions must be >3 times the background noise. 5. At least one ion in the M-70 cluster must be present. 6. Evaluate PCBs in the Cl-3 to Cl-7 range for coeluting PCBs. See SOP Section 11.1.3. 7. Examine data for presence of PCB of higher chlorination level if both ions and M-70 ions are present and the ratio does not fall within acceptable limits.	1. If identification criteria are not all met, but in the judgement of the operator the target compound is present, proceed with quantitation and document reasoning in the data package.
Equipment Blank Analysis	1 per sampling equipment and after collection of 10 samples.	Compounds concentrations must be <reporting limit.	1. Investigate problem; reanalyze to verify laboratory cross contamination is not a factor. 2. Notify QAO Officer since resampling may be necessary.
Field Duplicate Analysis	Collected every 10 samples.	Aqueous: RPD ≤50% for results > 5xCRQL. Soils: RPD ≤100% for results >5xCRQL. For Results <5xCRQL must agree within ±2xCRQL for aqueous and soils.	No corrective action required of the laboratory since the laboratory will not know the identity of the field duplicate samples. If these criteria are not met, sample results will be evaluated on a case by case basis during the validation process.

Table 7D. *PCBs Method 680 by Selected Ion Monitoring (SIM) Mode Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Laboratory Corrective Action
LCS Analysis	1 per 20 samples of similar matrix extracted at the same times. LCSs must be spiked with target compounds at the concentration specified in the SOP.	Percent recoveries must be within laboratory control limits in Section 5 of the SOP.	1. Reanalyze and examine results of other QC analyses. 2. If the percent recovery is above laboratory control limits (biased high) and the affected compound is not detected in the associated samples, corrective action is not required; document in case narrative. 3. If percent recovery is below laboratory control limits or <10%, reanalyze the LCS one additional time. If recoveries remain below limits and other QC criteria (surrogate, internal standards, calibration) have been met, notify QAO and document in case narrative report. 4. If recoveries are below laboratory control limits and additional QC excursions are observed, locate and correct problem, recalibrate instrument and re-extract and/or re-analyze samples since last satisfactory LCS. If samples requiring re-extraction or reanalysis over holding time requirements, notify the QAO immediately prior to proceeding since resampling may be required.
Quantitation	Samples, blanks, and QC data.	1. Internal standard method. 2. Verify concentration is within linear calibration range.	1. If concentration is above linear calibration range, dilute sample and reanalyze. Dilution should result in concentration in the upper calibration range of the instrument. 2. Perform appropriate PCB cleanup procedures as necessary to minimize sample matrix effects.
Cleanup	Acid cleanup prior to analysis. Gel permeation cleanup as necessary. Sulfuric cleanup if higher levels of sulfur present.	Not Applicalble	Not Applicable

Note
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QAO* indicates that communications with the QAO will be documented and included in the data packages.

Table 7E. *Metals SW-846 Method 6010B, Zinc SW-846 Method 7951, Copper SW-846 Method 7211, Mercury SW-846 Method 7470A, 7471A, and Cyanide SW-846 Method 9010B/9012A Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Holding Times	Samples must be digested and analyzed within holding time.	Metals: Analyze 180 days from collection. Mercury: Analyze 28 days from collection. Cyanide: Analyze 14 days from collection.	If holding times are exceeded for initial or any reanalyses required due to QC excursions, notify the QAO immediately since resampling may be required.
Calibration Verification (ICV, CCV)	Two point calibration for ICP. Five point calibration for remaining methods. Calibrate according to method and each time instrument is set up; verify at more frequent of 10% or each 2 hours. Also verify at the end of each run. Analyze highest mix std. before sample analysis. (ICP only) Std. at or below the PQL should be analyzed after initial cal. Mercury standard should be less than or equal to 5 times the PQL.	90% to 110% of expected value for ICP AA, colorimeter, and spectrophotometer. 80% to 120% of expected true value for Mercury. Highest std. mix ± 5% of true value for ICP. Correlation coefficient for first or second order curve must be ≥0.995.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate. 3. Document corrective action - samples cannot be analyzed until calibration control limit criteria have been met.
Calibration Blank	At beginning and end of run and at a rate of 10% during run.	Less than PQL.	1. Identify and correct problem. 2. If criteria are still not met, recalibrate. 3. Document corrective action - samples cannot be analyzed until blank control limit criteria have been met.
Preparation Blank Analysis	1 per batch of samples digested, or 1 in 20, whichever is greater.	Less than PQL.	1. Reanalyze blank. 2. If limits are still exceeded, clean instrument and recalibrate analytical system and reprep and reanalyze affected samples if detected. 3. Document corrective action - samples cannot be analyzed until blank criteria are met.

Table 7E. *Metals SW-846 Method 6010B, Zinc SW-846 Method 7951, Copper SW-846 Method 7211, Mercury SW-846 Method 7470A, 7471A, and Cyanide SW-846 Method 9010B/9012A Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Field / Equipment Blank Analysis	Collected one per sampling equipment and after every 10 samples.	Less than PQL	1. Investigate problem, contact QAO. 2. Write an explanation.
Laboratory Control Sample Analysis	Every 20 samples or each digestion batch. Prepared independently from calibration stds.	Recovery within laboratory control limits.	1. Reanalyze LCS and examine results of other QC analyses. 2. If recovery is still outside limits, and other QC criteria are met, contact QAO. 3. If other QC criteria have not been met, stop analysis, locate and correct problem, recalibrate instrument and reanalyze samples since last satisfactory LCS. 4. Document corrective action.
Post Verification Spike Analysis	Every 20 samples or each digestion batch for hexavalent chromium.	Recovery within 75-125%.	1. Dilute sample and reanalyze. 2. If recovery is still outside limits, contact QAO.
Serial Dilution Analysis	Required when analyte concentration is >50 times the PQL after dilution for ICP.	An analysis of a 1:5 dilution of the sample should provide a result with 90% to 110% of the original determination (for concentrations 50x the PQL).	1. Qualify data. 2. Document corrective action.
Interference Check Sample Analysis	Beginning and end of each analytical run or twice during every 8 hours, whichever is more frequent for ICP.	Percent recovery of all elements should be between 80% and 120%.	1. Reanalyze. 2. If limits are still exceeded, adjust instrument. 3. Restart analytical run and reanalyze samples analyzed since last satisfactory ICS. 4. Document corrective action.
Matrix Spike Analysis	1 per group of similar concentration and matrix, 1 per case of samples, or 1 in 20, whichever is greater.	Recovery within in-house control limits (does not apply if sample conc > 4 X spike conc). Spike must contain all analytes.	1. If LCS criteria are met, document in the case narrative.. 2. If LCS criteria are not met, examine other QC data to identify the source of the problem. 3. Reprepare/ reanalyze samples associated with the matrix spike and LCS. 4. Document corrective action.

Table 7E. *Metals SW-846 Method 6010B, Zinc SW-846 Method 7951, Copper SW-846 Method 7211, Mercury SW-846 Method 7470A, 7471A, and Cyanide SW-846 Method 9010B/9012A Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Laboratory Duplicate or Matrix Spike Duplicate Analysis	1 per group of similar concentration and matrix, 1 per case of samples, or 1 in 20, whichever is greater.	RPD less than in-house limits for conc > 5X PQL. Abs. difference less than 2X PQL otherwise.	1. Investigate problem and reanalyze. 2. Document corrective action.
Field Dup. Analysis	Collected 1 per matrix; every 10 samples of similar matrix	50% RPD for waters and 100% RPD for soil.	If these criteria are not met, sample results will be evaluated on a case by case basis.
Furnace Analysis	Two samples in each analytical batch must be injected in duplicate and spiked; method of standard additions is required when the sample absorbance or concentration is ≥ 50% of the spike concentration and the %recovery is not within control limits.	%Recovery 85% to 115%, Relative Standard Deviation <20%. MSA correlation coefficient > 0.995.	1. Dilute and reanalyze if <40% recovery, reanalyze 40%-60% recovery and no MSA. 2. If limits are still exceeded, qualify data. 3. Document corrective action.

Note
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Table 7F. *Inorganic Analyses TOC Method 9060, fluoride Method 300.0, orthophosphate Method 300.0, and total phosphorus Method 365.4 Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Holding Times	Samples must be digested and analyzed within holding time.	1. Total Organic Carbon, fluoride, total phosphorus: Analyze 28 days from collection. 2. Orthophosphate: Analyze 48 hours from collection.	If holding times are exceeded for initial or any reanalyses required due to QC excursions, notify the AQAO immediately since resampling may be required.
Calibration Verification (ICV, CCV)	TOC: Five point calibration every 3 months. ICV each time instrument is set up; verify with CCV at frequency of 10%. Fluoride, total phosphorus, orthophosphate: Minimum of 3 concentration levels. ICV and CCB following calibration and every 10th sample, and at the end of the sequence. Analyze reagent blank every batch.	TOC: 80% to 120% of expected value, if used, correlation coefficient for first or second order curve must be ≥ 0.995. Fluoride, total phosphorus, orthophosphate: 90% to 110% of expected value.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate. 3. Document corrective action - samples cannot be analyzed until calibration control limit criteria have been met.
Preparation Blank Analysis	1 per batch of samples digested, or 1 in 20, whichever is greater.	Less than PQL.	1. Reanalyze blank. 2. If limits are still exceeded, clean instrument and recalibrate analytical system and reprep and reanalyze affected samples if detected. 3. Document corrective action - samples cannot be analyzed until blank criteria are met.
Laboratory Control Sample Analysis (where applicable)	Every 20 samples or each digestion batch. Prepared independently from calibration standards.	TOC: Recovery within 80% to 120%. Fluoride, total phosphorus, orthophosphate: Recovery within 90% to 110%.	1. Reanalyze LCS and examine results of other QC analyses. 2. If recovery is still outside limits, and other QC criteria are met, contact AQAO. 3. If other QC criteria have not been met, stop analysis, locate and correct problem, recalibrate instrument and reanalyze samples since last satisfactory LCS. 4. Document corrective action.

Table 7F. *Inorganic Analyses TOC Method 9060, fluoride Method 300.0, orthophosphate Method 300.0, and total phosphorus Method 365.4 Quality Control Requirements and Corrective Actions.**

Audit	Frequency	Control Limits	Corrective Action
Matrix Spike Analysis	1 per group of similar concentration and matrix, 1 per case of samples, or 1 in 20, whichever is greater. Fluoride, total phosphorus, orthophosphate: Sample concentration can't be less than 4 times the MDL.	Recovery within in-house control limits (does not apply if sample conc > 4 X spike conc).	1. If LCS criteria are met, document in the case narrative.. 2. If LCS criteria are not met, examine other QC data to identify the source of the problem. 3. Reprepare/ reanalyze samples associated with the matrix spike and LCS. 4. Document corrective action.
Laboratory Duplicate or Matrix Spike Duplicate Analysis	1 per group of similar concentration and matrix, 1 per case of samples, or 1 in 20, whichever is greater. Fluoride, total phosphorus, orthophosphate: Sample concentration must be greater than 5 times the MDL.	RPD less than in-house limits for concentrations > 5X PQL. Absolute difference less than PQL otherwise.	1. Investigate problem and reanalyze. 2. Document corrective action.
Field / Equipment Blank Analysis	Collected one per sampling equipment and after every 10 samples.	Less than PQL	1. Investigate problem, contact QAO. 2. Write an explanation.
Field Dup. Analysis	Collected 1 per matrix; every 10 samples of similar matrix	50% RPD for waters and 100% RPD for soil.	No corrective action required of the laboratory since the laboratory will not know the identity of the field duplicate samples. If these criteria are not met, sample results will be evaluated on a case by case basis.

Note
*indicates that d ata validation will be performed in accordance with QA/QC criteria established in these tables and the analytical methods. Excursions from QA/QC criteria will be qualified based on guidance provided in Section 9.2.2 of this QAPP.
QAO* indicates that communications with the QAO will be documented and included in the data packages.

Table 7G. *PCDDs/PCDFs Method 8280 A Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
Holding Times	Samples must be extracted and analyzed within holding time.	Extract within 30 days of VTSR for extraction, 40 days to analysis for solid samples. Cleanup using alumina, silica gel, and activated carbon.	If holding times are exceeded for initial or any reanalyses required due to QC excursions, notify QAO since resampling may be required.
MS Tuning	At the beginning and end of the 12 hour sequence. Prior to calibration, blank, sample and QC sample analysis.	Tune instrument using FC43 in accordance with method 8280A Total cycle time must be ≤ 1.0 second.	1. Identify and correct problem. 2. Re-tune the mass spectrometer; samples must not be analyzed until tuning criteria are met.
GC Column Performance Check Standard (Window defining mixture)	At the beginning of 12 hour sequence, prior to initial calibration or continuing calibration standard.	Must contain the first and last for each homologous series tetra- through heptachlorinated congeners. It also contains other TCDD isomers and $^{13}C_{12}$-2,3,7,8-TCDD to document resolution. Method 8280A Section 7.13.2 must be met. Chromatographic resolution between 2378-TCDD and the peaks representing any other unlabeled TCDD isomers must be resolved with a valley ≤25%. GC column performance standard is also used to determine the retention times for quantitative determination of the non -2378-substituted congeners. All peaks must be labeled and identified on the chromatograms, additionally, first eluters should be labeled with the letter F, and the last eluters with the letter L.	1. Identify and correct problems 2. Reanalyze; samples must not be analyzed until GC column performance check criteria are established.
Selective Ion Monitoring (SIM) Descriptors	Acquire SIM data for all ions listed in the five descriptors.	The ions listed in Method 8280A, Table 7 must be monitored. The tetra and penta chlorinated dioxins and furans can be combined.	1. Identify and correct problems. 2. Document in the case narrative.

Table 7G. *PCDDs/PCDFs Method 8280 A Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
Initial Calibration	Before any samples are analyzed, when criteria are exceeded for continuing calibration, and if calibration , sample fortification (internal standard) or recovery standard solutions are replaced with a different lot. Calibration standard consist of 17 unlabeled target compounds spiked with the 5 labeled internals, and 2 labeled recovery standards. Additionally, 7 labeled PCDDs/PCDFs are used by the laboratory as surrogate and alternative standards. Use 8290 Table 5.	Minimally five concentrations, using the calibration range specified in Table 1 of EPA method 8280A. Relative ion abundance criteria specified in EPA method 8280A Table 9 must be met. Instrument sensitivity: the S/N ration must $\geq$10. On each selected ion current profile (SICP) and for each GC signal corresponding to the elution of a target analyte and its labeled standard, the S/N must be $\geq$2.5. The S/N measurement is required for each peak with a S/N <5. The result of the calculation must appear on the SICP above the GC peak in question. RSD $\leq$15% relative to the internal standard and recovery standards.	1. Identify and correct problem. 2. Recalibrate instrument; samples must not be analyzed until initial calibration criteria are met.
Continuing Calibration	Analyze at beginning of the 12 hour sequence following the GC performance check standard.	Relative ion abundance criteria specified in EPA method 8280A Table 9 must be met. If %D $\leq$30% for the 17 unlabeled standards and $\leq$30% for the nine labeled standards use average RRF for quantitation.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate; samples cannot be analyzed until continuing calibration criteria are met.
Internal Standards	Samples, blanks, MS/MSDs, LCSs are spiked with labeled internal standards prior to extraction. The laboratory will use 1,2,3,6,7,8-HxCDF in place of method required 1,2,3,4,7,8-HxCDF because 1,2,3,4,7,8-HxCDF is used as a surrogate.	Percent recoveries must be within 25% to 150%. Ion abundance criteria specified in EPA method 8280A must be met.	1. Re-extract and/or re-analyze. 2. If re-extraction and re-analysis does not solve problem and other QC criteria were met, submit both runs and discuss in narrative report.

Table 7G. *PCDDs/PCDFs Method 8280 A Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
Surrogate or Alternate Standards	Samples, blanks, and MS/MSDs are spiked with 2,3,7,8-TCDD.	Percent recoveries must be within 8280A criteria.	1. Re-extract and/or re-analyze. 2. If re-extraction and re-analysis does not solve problem and other QC criteria were met, submit both runs and discuss in narrative report
Recovery Standard	Consists of 13C12 1,2.3.4-TCDD and 13C12 1,2,3,7,8,9-HxCDD which are added to field samples, blanks, QC samples prior to sample injection.	Recovery standard are used to calculate internal standard recovery. The recovery standard must elute within 10 seconds of the same standards in the continuing calibration at the start of the analytical sequence.	1. Re-extract and/or re-analyze. 2. If re-extraction and re-analysis does not solve problem and other QC criteria were met, submit both runs and discuss in narrative report
Method Blank Analysis	1 per 20 samples of similar matrix extracted at the same time, analyzed between the calibration standard and samples.	Compound concentrations must be <CRQL.	1. Reanalyze. 2. If limits are still exceeded, re-extract and reanalyze method blank and associated samples if holding times have not elapsed. 3. If holding times have elapsed, contact QAO Manager since resampling may be required.
MS/MSD Analysis	1 per matrix type and every 20 samples of similar matrix. MS/MSDs must be spiked with compounds specified in the Method 8290, Table 5.	Recovery within 50% to 150%. RPD within 50%.	1. Reanalyze. 2. If recovery or RPD is still outside limits, document in case narrative report.
Duplicate Analysis	1 per sample batch.	RPD within 50%.	1. Reanalyze. 2. If RPD is still outside limits, document in case narrative report.

Table 7G. *PCDDs/PCDFs Method 8280 A Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
Identification	Samples, blanks, and QC data.	For 2,3,7,8-substituted congeners, which has labeled internal or recovery standard present, the retention time of sample component for the two quantitation ions must be within -1 to +3 seconds of the labeled standard. For 2,3,7,8-substituted congeners, which do not have labeled internal standard present, the retention time must fall within 0.005 retention time units of the relative retention times measured in the continuing calibration. For the non-2,3,7,8 substituted compounds (tetra through octa, 119 congeners), the retention time must be within the corresponding homologous retention time established by the GC column performance check standard. The ion current response for both ions must reach a maximum with ±2 seconds. Ion abundance rations specified in Method 8280A Table 9 must be met. Signal-to-noise ratio (S/N): all ion current intensities must be $\geq$2.5 times for positive identification of a PCDD/PCDF compound or a group of coeluting isomers. The identification of PCDFs are made only if no S/N $\geq$2.5 is detected at the same retention time (±2 seconds) in the corresponding polychlorinated diphenyl ether channel.	1. If identification criteria are not all met, but in the judgement of the operator the target compound is present, proceed with quantitation and document reasoning in the data package.

Table 7G. *PCDDs/PCDFs Method 8280 A Quality Control Requirements and Corrective Actions*			
Audit	**Frequency**	**Control Limits**	**Laboratory Corrective Action**
Identification	Samples, blanks, and QC data.	Verify the presence of 1,2,8,9-TCDD and 1,3,4,6,8-PeCDF in the daily performance check.	1. Identify problem and correct.
Quantitation	Samples, blanks, and QC data.	Internal and external standard method. For OCDD, OCDF and homologous series with only one 2,3,7,8-substituted isomer (TCDD, PeCDD, HpCDD, TCDF) the mean RF is used (see Method 8290 Table 4). For homologous series with more than one 2378-substituted isomers the mean RF for individual 2,3,7,8-substituted congeners is used (PeCDF, HxCDF, HxCDD, HpCDF - see Method 8290 Table 4, 7.7.1.4.6.2). Based on the six-point calibration curve for each homologue. Verify saturation has not occurred. Every effort must be made to meet specified CRQL requirements. Soil and sediment samples concentrations must be corrected to dry weight. If interferences are present, additional cleanup may be required to achieve CRQLs. If 2,3,7,8-TCDF is detected on DB-5 column, the sample extract must be reanalyzed on DB-225 column or the equivalent to resolve 2,3,7,8-TCDF.	1. If peak is saturated, dilute sample and reanalyze. 2. If 2378-substituted PCDD/PCDF concentration is greater than the calibration limit, a second analysis using 1/10 aliquot is performed (see Method 8290, Section 7.9.3.1) 3. Perform appropriate cleanup procedures as necessary to minimize sample matrix effects.
Sample Specific Estimated Detection Limit (EDL)	Sample specific EDL is the concentration of a five analyte required to produce a signal with a peak height of at least 2.5 times the background signal.	Calculate an EDL for each 2,3,7,8-substituted congener that is not identified.	Not applicable

Table 7G. *PCDDs/PCDFs Method 8280 A Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
Estimated Maximum Possible Concentration (EMPC)	All samples, blanks, QC data.	Samples characterized by a response above background level with a S/N of at least 2.5 for both quantitation ions.	When the response of a signal having the same retention time as a 2378-substituted congener has a S/N in excess of 2.5 and does not meet any of the other identification criteria, calculate the EMPC according to method 8290, Section 7.9.5.2.
Equipment Blank Analysis	1 per sampling equipment and after collection of 10 samples.	Compounds concentrations must be <CRQL.	1. Investigate problem; reanalyze to verify laboratory cross contamination is not a factor. 2. Notify QAO Officer since resampling may be necessary.
Field Duplicate Analysis	Collected every 10 samples.	Aqueous: RPD ≤50% for results > 5xCRQL. Soils: RPD ≤100% for results >5xCRQL. For Results <5xCRQL must agree within ±2xCRQL for aqueous and soils.	No corrective action required of the laboratory since the laboratory will not know the identity of the field duplicate samples. If these criteria are not met, sample results will be evaluated on a case by case basis during the validation process.

Note
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QAO* indicates that communications with the QAO will be documented and included in the data packages.

Table 7H. *PCDDs/PCDFs Method 8290 Quality Control Requirements and Corrective Actions*			
Audit	**Frequency**	**Control Limits**	**Laboratory Corrective Action**
Holding Times	Samples must be extracted and analyzed within holding time.	Extract within 30 days of VTSR for extraction, 40 days to analysis for solid samples. Cleanup using alumina, silica gel, and activated carbon.	If holding times are exceeded for initial or any reanalyses required due to QC excursions, notify QAO since resampling may be required.
MS Tuning	At the beginning and end of the 12 hour sequence. Prior to calibration, blank, sample and QC sample analysis.	Tune instrument using PFK in accordance with method 8290, Section 7.6.2.2, and Table 6. Minimally, the mass spectrometer must have a static resolving power at least 10,000 (10% valley). The laboratory will verify resolution criteria using masses 304.9824 or any other signal close to m/z 303.9016 (TCDF). Verify PFK the exact mass of m/z 380.9760 is within 5 ppm of the required value. Total cycle time must be $\leq$ 1.0 second.	1. Identify and correct problem. 2. Re-tune the mass spectrometer; samples must not be analyzed until tuning criteria are met.

Table 7H. *PCDDs/PCDFs Method 8290 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
GC Column Performance Check Standard (Window defining mixture)	At the beginning of 12 hour sequence, prior to initial calibration or continuing calibration standard.	Must contain the first and last for each homologous series tetra- through heptachlorinated congeners. It also contains other TCDD isomers and $^{13}C_{12}$-2,3,7,8-TCDD to document resolution (refer to Table 7 of method 8290). Method 8290 Section 8.2.1 must be met. Chromatographic resolution between 2378-TCDD and the peaks representing any other unlabeled TCDD isomers must be resolved with a valley ≤25%. GC column performance standard is also used to determine the retention times for quantitative determination of the non -2378-substituted congeners. All peaks must be labeled and identified on the chromatograms, additionally, first eluters should be labeled with the letter F, and the last eluters with the letter L.	1. Identify and correct problems 2. Reanalyze; samples must not be analyzed until GC column performance check criteria are established.
Selective Ion Monitoring (SIM) Descriptors	Acquire SIM data for all ions listed in the five descriptors.	The ions listed in Method 8290, Table 6 must be monitored. The tetra and penta chlorinated dioxins and furans can be combined.	1. Identify and correct problems. 2. Document in the case narrative.

Table 7H. *PCDDs/PCDFs Method 8290 Quality Control Requirements and Corrective Actions*			
Audit	**Frequency**	**Control Limits**	**Laboratory Corrective Action**
Initial Calibration	Before any samples are analyzed, when criteria are exceeded for continuing calibration, and if calibration , sample fortification (internal standard) or recovery standard solutions are replaced with a different lot. Calibration standard consist of 17 unlabeled target compounds spiked with the 5 labeled internals, and 2 labeled recovery standards. Additionally, 7 labeled PCDDs/PCDFs are used by the laboratory as surrogate and alternative standards. Use 8290 Table 5.	Minimally six concentrations, using the calibration range specified in Table 5 of EPA method 8290 except for tetra congeners in which the laboratory will use calibration range of 0.5 picogram (pg)/microliter (uL) to 100 pg/uL. Relative ion abundance criteria specified in EPA method 8290 Table 8 must be met. Instrument sensitivity: the S/N ration must $\geq$10. On each selected ion current profile (SICP) and for each GC signal corresponding to the elution of a target analyte and its labeled standard, the S/N must be $\geq$2.5. The S/N measurement is required for each peak with a S/N <5. The result of the calculation must appear on the SICP above the GC peak in question. RSD $\leq$20% for the 17 unlabeled PCDDs/PCDFs relative to the internal standard and $\leq$30% for the nine labeled internal standards relative to the recovery standards.	1. Identify and correct problem. 2. Recalibrate instrument; samples must not be analyzed until initial calibration criteria are met.

Table 7H. *PCDDs/PCDFs Method 8290 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
Continuing Calibration	Analyze at beginning of the 12 hour sequence following the GC performance check standard and at the end of the 12 hour sequence.	Relative ion abundance criteria specified in EPA method 8290 Table 8 must be met. If %D ≤20% for the 17 unlabeled standards and ≤30% for the nine labeled standards use average RRF for quantitation. If %D ≤25% (or ≤35% for labeled standards) for the ending continuing calibration standards only, quantitate results using average of RRF from the beginning and ending continuing calibration standards.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate; samples cannot be analyzed until continuing calibration criteria are met.
Internal Standards	Samples, blanks, MS/MSDs, LCSs are spiked with labeled internal standards prior to extraction. The laboratory will use 1,2,3,6,7,8-HxCDF in place of method required 1,2,3,4,7,8-HxCDF because 1,2,3,4,7,8-HxCDF is used as a surrogate.	Percent recoveries must be within 40% to 130%. HPCDD, HPCDF, and OCDD percent recoveries must be within 25 to 130%. Ion abundance criteria specified in EPA method 8290 must be met.	1. Re-extract and/or re-analyze. 2. If re-extraction and re-analysis does not solve problem and other QC criteria were met, submit both runs and discuss in narrative report.
Surrogate or Alternate Standards	Samples, blanks, and MS/MSDs are spiked with seven labeled standards after extraction and prior to cleanup.	Percent recoveries must be within 40% to 130% for the tetra through hexachlorinated surrogates and 25% to 130% fro the heptachlorinated surrogates.	1. Re-extract and/or re-analyze. 2. If re-extraction and re-analysis does not solve problem and other QC criteria were met, submit both runs and discuss in narrative report
Recovery Standard	Consists of 13C12 1,2.3.4-TCDD and 13C12 1,2,3,7,8,9-HxCDD which are added to field samples, blanks, QC samples prior to sample injection.	Recovery standard are used to calculate internal standard recovery.	Not applicable

Table 7H. *PCDDs/PCDFs Method 8290 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
Method Blank Analysis	1 per 20 samples of similar matrix extracted at the same time, analyzed between the calibration standard and samples.	Compound concentrations must be <CRQL.	1. Reanalyze. 2. If limits are still exceeded, re-extract and reanalyze method blank and associated samples if holding times have not elapsed. 3. If holding times have elapsed, contact QAO Manager since resampling may be required.
MS/MSD Analysis	1 per matrix type and every 20 samples of similar matrix. MS/MSDs must be spiked with compounds specified in the Method 8290, Table 5.	Recovery within laboratory limits. RPD within 20%.	1. Reanalyze. 2. If recovery or RPD is still outside limits, document in case narrative report.
Duplicate Analysis	1 per sample batch.	RPD within 20%.	1. Reanalyze. 2. If RPD is still outside limits, document in case narrative report.

Table 7H. *PCDDs/PCDFs Method 8290 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
Identification	Samples, blanks, and QC data.	For 2,3,7,8-substituted congeners, which has labeled internal or recovery standard present, the retention time of sample component for the two quantitation ions must be within -1 to +3 seconds of the labeled standard. (Method 8290 Tables 2 and 3, for 10 congeners) For 2,3,7,8-substituted congeners, which do not have labeled internal standard present, the retention time must fall within 0.005 retention time units of the relative retention times measured in the continuing calibration. (Method 8290 Table 3, for 6 congeners) For the non-2,3,7,8 substituted compounds (tetra through octa, 119 congeners), the retention time must be within the corresponding homologous retention time established by the GC column performance check standard. The ion current response for both ions must reach a maximum with ±2 seconds. Ion abundance rations specified in Method 8290 Table 8 must be met. Signal-to-noise ratio (S/N): all ion current intensities must be ≥2.5 times for positive identification of a PCDD/PCDF compound or a group of coeluting isomers. The identification of PCDFs are made only if no S/N ≥2.5 is detected at the same retention time (±2 seconds) in the corresponding polychlorinated diphenyl	1. If identification criteria are not all met, but in the judgement of the operator the target compound is present, proceed with quantitation and document reasoning in the data package.

Table 7H. *PCDDs/PCDFs Method 8290 Quality Control Requirements and Corrective Actions*			
Audit	**Frequency**	**Control Limits**	**Laboratory Corrective Action**
Identification	Samples, blanks, and QC data.	Verify the presence of 1,2,8,9-TCDD and 1,3,4,6,8-PeCDF in the daily performance check.	1. Identify problem and correct.
Quantitation	Samples, blanks, and QC data.	Internal and external standard method. For OCDD, OCDF and homologous series with only one 2,3,7,8-substituted isomer (TCDD, PeCDD, HpCDD, TCDF) the mean RF is used (see Method 8290 Table 4). For homologous series with more than one 2378-substituted isomers the mean RF for individual 2,3,7,8-substituted congeners is used (PeCDF, HxCDF, HxCDD, HpCDF - see Method 8290 Table 4, 7.7.1.4.6.2). Based on the six-point calibration curve for each homologue. Verify saturation has not occurred. Every effort must be made to meet specified CRQL requirements. Soil and sediment samples concentrations must be corrected to dry weight. If interferences are present, additional cleanup may be required to achieve CRQLs. If 2,3,7,8-TCDF is detected on DB-5 column, the sample extract must be reanalyzed on DB-225 column or the equivalent to resolve 2,3,7,8-TCDF.	1. If peak is saturated, dilute sample and reanalyze. 2. If 2378-substituted PCDD/PCDF concentration is greater than the calibration limit, a second analysis using 1/10 aliquot is performed (see Method 8290, Section 7.9.3.1) 3. Perform appropriate cleanup procedures as necessary to minimize sample matrix effects.
Sample Specific Estimated Detection Limit (EDL)	Sample specific EDL is the concentration of a five analyte required to produce a signal with a peak height of at least 2.5 times the background signal.	Calculate an EDL for each 2,3,7,8-substituted congener that is not identified.	Not applicable

Table 7H. *PCDDs/PCDFs Method 8290 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Laboratory Corrective Action
Estimated Maximum Possible Concentration (EMPC)	All samples, blanks, QC data.	Samples characterized by a response above background level with a S/N of at least 2.5 for both quantitation ions.	When the response of a signal having the same retention time as a 2378-substituted congener has a S/N in excess of 2.5 and does not meet any of the other identification criteria, calculate the EMPC according to method 8290, Section 7.9.5.2.
Equipment Blank Analysis	1 per sampling equipment and after collection of 10 samples.	Compounds concentrations must be <CRQL.	1. Investigate problem; reanalyze to verify laboratory cross contamination is not a factor. 2. Notify QAO Officer since resampling may be necessary.
Field Duplicate Analysis	Collected every 10 samples.	Aqueous: RPD ≤50% for results > 5xCRQL. Soils: RPD ≤100% for results >5xCRQL. For Results <5xCRQL must agree within ±2xCRQL for aqueous and soils.	No corrective action required of the laboratory since the laboratory will not know the identity of the field duplicate samples. If these criteria are not met, sample results will be evaluated on a case by case basis during the validation process.

Note
*indicates that d ata validation will be performed in accordance with QA/QC criteria established in these tables and the analytical methods. Excursions from QA/QC criteria will be qualified based on guidance provided in Section 9.2.2 of this QAPP.
QAO* indicates that communications with the QAO will be documented and included in the data packages.

Table 7I. *Volatile, Semivolatile, PCB, Dioxin, and Dibenzofuran Compounds using USEPA Methods TO-1, TO-13, TO-4, and TO-9 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Corrective Action
Holding Times	Samples must be extracted and analyzed within holding time. Calibration of sampling system is performed as per USEPA Methods TO-1, TO-13, TO-4, TO-9.	Analyze within 7 days of sample collection.	If holding times are exceeded for initial or any reanalyses required due to QC excursions, notify the QAO* immediately since resampling may be required.
For TO-1, TO-13, TO-4 - MS Tuning	Once every 12 hours prior to initial calibration and calibration verification.	1. Tune key ions and abundance criteria listed in the method must be met for all ions and analyses must be performed within 12 hours of injection of the tune. 2. Part of the tune peak will not be background subtracted to meet tune criteria. 3. Documentation of all tune analyses and evaluations must be included in the data packages.	1. Tune the mass spectrometer. 2. Document corrective action in the case narrative - **samples cannot be analyzed until control limit criteria have been met.**
For TO-9 - MS Tuning	At the beginning and end of the 12 hour sequence. Prior to calibration, blank, sample and QC sample analysis.	Tune instrument using PFK in accordance with method. Minimally, the mass spectrometer must have a static resolving power at least 10,000 (10% valley). The laboratory will verify resolution criteria using masses 304.9824 or any other signal close to m/z 303.9016 (TCDF). Verify with PFK the exact mass of m/z 318.979 is within 5 ppm of the required value. Total cycle time must be ≤1.0 second.	1. Identify and correct problem. 2. Re-tune the mass spectrometer; samples must not be analyzed until tuning criteria are met.

Table 7I. *Volatile, Semivolatile, PCB, Dioxin, and Dibenzofuran Compounds using USEPA Methods TO-1, TO-13, TO-4, and TO-9 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Corrective Action
For TO-9 - GC Column Performance Check Standard (Window defining mixture)	At the beginning of 12 hour sequence, prior to initial calibration or continuing calibration standard.	Method peak separation criteria must be met. All peaks must be labeled and identified on the chromatograms, additionally, first eluters should be labeled with the letter F, and the last eluters with the letter L.	1. Identify and correct problems 2. Reanalyze; samples must not be analyzed until GC column performance check criteria are established.
Initial Calibration	Prior to sample analysis and when calibration verification criteria are not met. Initial calibration will contain all target analytes in each standard.	1. Five concentrations bracketing expected concentration range for all compounds of interest; one standard must be near the PQL. 2. %RSD ≤20. 3. For compounds with %RSD >20, quantification must be performed using a separate calibration curve and the COD must be ≥ 0.99. For TO-9 - 4. Isotopic ratio criteria in method must be met. 5. Signal to noise criteria in method must be met.	1. Identify and correct problem. 2. If criteria are still not met, recalibrate. 3. Document corrective action in the case narrative - **samples cannot be analyzed until calibration criteria are met**.
Calibration Verification	Every 12 hours, following tune. Calibration verification will contain all target analytes in each standard at a concentration that is representative of the midpoint of the initial calibration.	1. Within method specified criteria percent difference (%D) ≤ 20. For TO-9 - 2. Isotopic ratio criteria in method must be met. 3. Signal to noise criteria in method must be met.	1. Reanalyze. 2. If criteria are still not met, identify and correct problem, recalibrate and notify QAO*. 3. Document corrective action in the case narrative - **samples cannot be analyzed until calibration control limit criteria are met**.

Table 7I. *Volatile, Semivolatile, PCB, Dioxin, and Dibenzofuran Compounds using USEPA Methods TO-1, TO-13, TO-4, and TO-9 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Corrective Action
Preparation Blank Analysis	Prepared with each batch of no more than 20 analytical samples.	Less than PQL.	1. Reanalyze blank. 2. If limits are still exceeded, clean instrument, recalibrate analytical system and reextract/reanalyze as appropriate all samples if detected for same compounds as in the blank. 3. Document corrective action in the case narrative - **samples cannot be analyzed until blank criteria have been met.**
Backup cartridge Analysis	During each sampling event.	Less than 20% of the concentration of the compounds present in the front cartridge or must be equivalent to the blank cartridge, whichever is less.	If these criteria are not met, sample results will be evaluated on a case by case basis.
Process Blank Analysis	Prepared with each batch of no more than 20 analytical samples.	Less than 10 ng per cartridge, (less than 100 ng for PCBs) filter assembly for target compounds.	1. Reanalyze blank. 2. Document in the case narrative.
Field / Equipment Blank Analysis	Collected for equipment and one per 10 samples	Less than PQL.	1. Investigate problem, contact QAO*. 2. Write an explanation in the case narrative.
For TO-1, TO-13, TO-4 - Internal Standards	All samples and blanks.	1. Response -50% - +100% of the internal standards from the continuing cal of the day. 2. RT must be ± 30 sec. from calibration verification of that sequence.	1. Reanalyze. 2. If recovery is still outside criteria, report both analyses, and contact the QAO*. 3. Document corrective action in the case narrative. Special Circumstances: If matrix interferences is present (as demonstrated by the lab and documented in the case narrative): 1. Reanalyze (may be at a higher dilution) 2. If internal standard is >10%, report both runs 3. If internal standard is <10%, report both runs and contact the QAO*.
For TO-9 - Internal Standards	Samples, blanks, MS/MSDs are spiked with labeled internal standards prior to extraction.	Percent recoveries must be within 40% to 120%.	1. Re-extract and/or re-analyze. 2. If re-extraction and re-analysis does not solve problem and other QC criteria were met, submit both runs and discuss in narrative report.

Table 7I. *Volatile, Semivolatile, PCB, Dioxin, and Dibenzofuran Compounds using USEPA Methods TO-1, TO-13, TO-4, and TO-9 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Corrective Action
Surrogate Spike	All samples and blanks.	Recovery within laboratory control limits.	1. Reanalyze if one for TO-1, TO-4, or more than one AE or one BN fails for TO-13, or if any one surrogate %R is < 10%. 2. If recovery is still outside control limits and if the recovery is < 10%, reextract if still in holding time (where applicable). 3. If recovery is still outside control limits, and if recovery is >10%, report both analyses. 3. Document corrective action in the case narrative. Special Circumstances: If matrix interference is present (as demonstrated by the lab and documented in the case narrative): 1. Reanalyze (may be at a higher dilution) 2. If surrogate recovery is >10%, report both runs. 3. If surrogate recovery is <10%, report both runs and contact QAO*.
Matrix Spike (MS) Analysis	1 per group of similar concentration and matrix, 1 per case of samples, or 1 in 20, whichever is greater. Spike must contain target analytes.	Recovery and RPD within laboratory control limits.	1. Reanalyze if <10%. 2. If reanalysis is still < 10%, report both analyses and document in the case narrative. 3. If >10%, and LCS criteria are met, document in the case narrative. 4. If LCS criteria are exceeded also, examine other QC data for source of problem; ie surrogate recoveries for extraction efficiency and calibration data for instrument performance issues and contact QAO* and re-extract or reanalyze samples and associated MS/MSD and LCSs as required.
Field Dup. Analysis	1 per matrix and analytical batch and every 10 samples of similar matrix.	25% RPD for air.	If these criteria are not met, sample results will be evaluated on a case by case basis.

Table 7I. *Volatile, Semivolatile, PCB, Dioxin, and Dibenzofuran Compounds using USEPA Methods TO-1, TO-13, TO-4, and TO-9 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Corrective Action
For TO-9 - Identification	Samples, blanks, and QC data.	For 2,3,7,8-substituted congeners, which has labeled internal or recovery standard present, the retention time of sample component for the two quantitation ions must be within -1 to +3 seconds of the labeled standard. For the non-2,3,7,8 substituted compounds, the retention time must be within the corresponding homologous retention time established by the GC column performance check standard. The ion current response for both ions must reach a maximum with ±1 scan. Ion abundance rations specified in Method must be met. Signal-to-noise ratio (S/N): all ion current intensities must be ≥2.5 times for positive identification of a PCDD/PCDF compound or a group of coeluting isomers.	1. If identification criteria are not all met, but in the judgement of the operator the target compound is present, proceed with quantitation and document reasoning in the data package.
Tentatively Identified Compounds	If required , for each sample and blank analysis. Non-target compounds will be reported using a Mass Spectral Library search.	not applicable	not applicable

Table 7I. *Volatile, Semivolatile, PCB, Dioxin, and Dibenzofuran Compounds using USEPA Methods TO-1, TO-13, TO-4, and TO-9 Quality Control Requirements and Corrective Actions*

Audit	Frequency	Control Limits	Corrective Action
Laboratory control limits	1. Generated with results for an analyte from a minimum of 20 sample analyses. The average of the sample results and the standard deviation are calculated. The internal warning limits are established at 2 times the standard deviation and the control limits are established at 3 times the standard deviation. The control limits are updated annually.	not applicable	not applicable

Notes:
*indicates that d ata validation will be performed in accordance with QA/QC criteria established in these tables and the analytical methods. Excursions from QA/QC criteria will be qualified based on guidance provided in Section 9.2.2 of this QAPP.
QAO* indicates that communications with the QAO will be documented and included in the data packages.
QAO* indicates that communications with the QAO will be documented and included in the data packages.

Table 8. *Preventive maintenance for field and analytical instrumentation (See also Savannah Laboratories & Environmental Services, Inc. Corporate Quality Assurance Plan, Section 10.0)*

Field or Analytical Instrument	Activity	Frequency
ICAP	Change pump tubing	daily
	Clean nebulizer	as needed
	Inspect filters	monthly, clean or replace as needed
	Clean spray chamber	as needed
	Clean and realign quartz torch	as needed
Leeman PS200 Mercury Analyzer and Autosampler	Inspect pump tubing	daily
	Inspect standard cup	daily
	Repack drying tube	daily, at minimum
	Inspect mixing coil	weekly, clean or replace as needed
	Inspect sample probe	monthly, clean or replace as needed
	Clean mercury lamp	as needed
Furnace	Remove and clean quartz windows	daily
	Inspect graphite tubes	daily
	Clean contact rings	daily, replace as needed
	Inspect filters	monthly, clean or replace as needed
	Adjust or replace D2 arc lamp	as needed
pH Meter	Clean or replace probe	as needed
Gas Chromatograph	Clean autosampler system	as needed, clean syringe and tubing, replace needles and tubing when necessary
	Check septa	daily, replace as needed
	Check column/injector	as needed
	Inspect gas cylinder	daily, change when pressure reads <500 psi
	Replace hydrocarbon/moisture trap	as needed
	Clean tape head and drive	as needed
Gas Chromatograph/Mass Spectrometer	Check column/injector	as needed
	Check septum	daily, replace as needed

Table 8. *Preventive maintenance for field and analytical instrumentation (See also Savannah Laboratories & Environmental Services, Inc. Corporate Quality Assurance Plan, Section 10.0)*

Field or Analytical Instrument	Activity	Frequency
	Inspect gas cylinder	daily, change when pressure reads <500 psi
	Replace hydrocarbon/moisture trap	as needed
	Replace splitless disc	as needed
	Clean autosampler	as needed, clean syringe and tubing, replace needles and tubing when necessary
	Change oil in rough pump	as needed
	Clean mass spectrometer	as needed
TOC Analyzer	Replace catalyst	as needed
	Check internal flow meters	monthly
	Check and clean detector windows	weekly
	Check fill levels of humidifiers	as needed
	Perform zero point calibration of syringe	monthly
Hydac® pH, temperature, and conductivity meter, Turbidity meter, HNu® PL-101 or DL-101 PID, Photovac MicroTIP® detector, Field gas chromatograph Neotronics Mini Gas 4® Portable 4-in-1 Multi-Gas Monitor (explosimeter), Dusttrak® Model 8520 RAM or equal, Geometrics 858 Cesium or 856AX TOTAL Field Magnetometer	Specific preventive maintenance procedures to be followed for field equipment are those recommended by the manufacturer. Critical spare parts will be kept on-site to reduce downtime.	as needed

Sources: Savannah Laboratories & Environmental Services, Inc., and O'Brien & Gere Engineers, Inc.

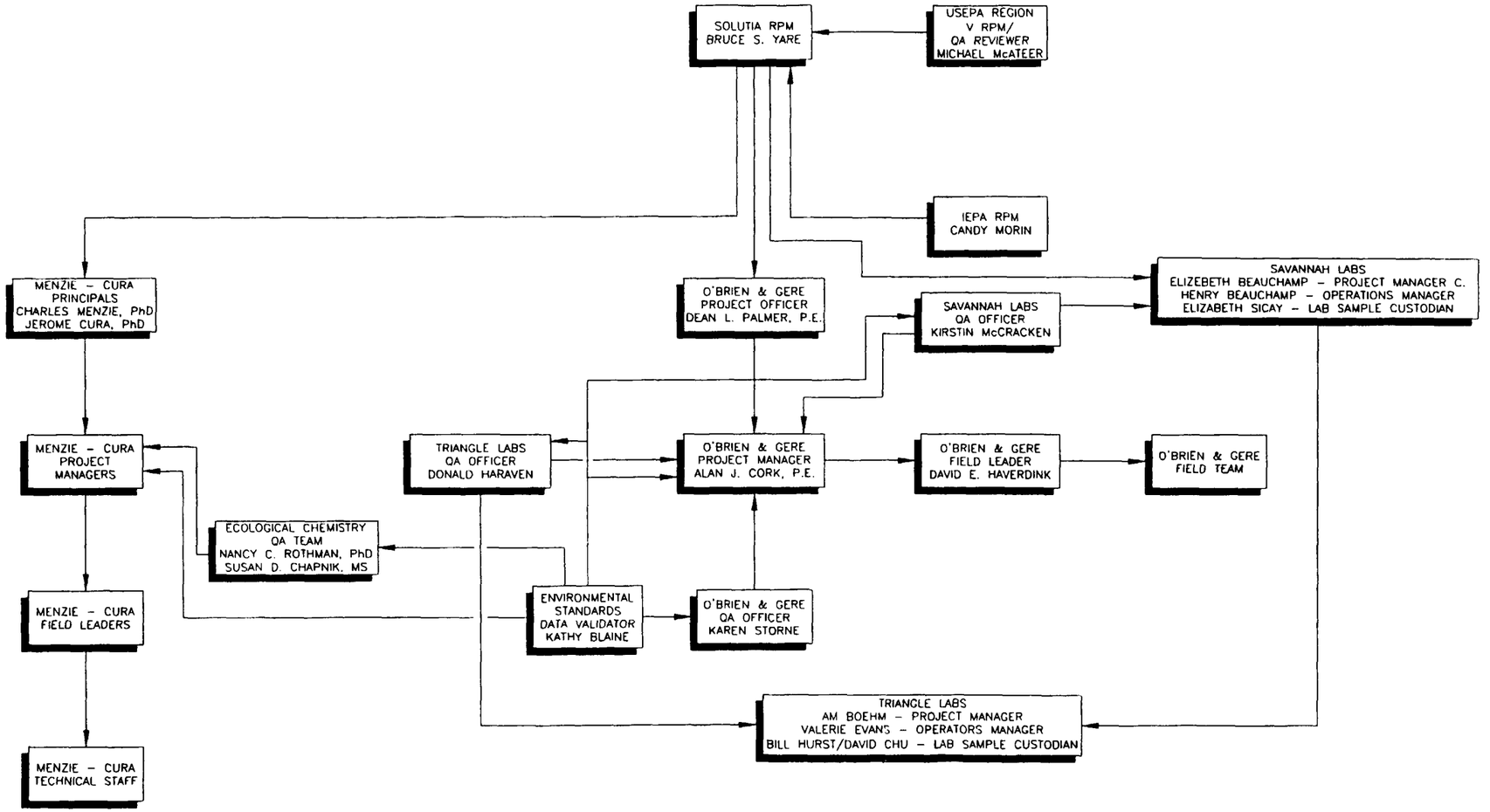
Table 9. *Preventive maintenance for analytical instrumentation*

Analytical Instrument	Activity	Frequency
Gas Chromatograph/Mass Spectrometer	Check column/injector	as needed
	Check septum	daily, replace as needed
	Inspect gas cylinder	daily
	Clean autosampler	as needed, clean syringe and tubing, replace needles and tubing when necessary
	Change oil in rough pump	as needed
	Clean mass spectrometer	as needed

Source: Triangle Laboratories, Inc.

FIGURES

FIGURE 1



SOLUTIA INC.
SAUGET AREA 1

PROJECT ORGANIZATION CHART SHOWING LINES OF AUTHORITY

8/2/99
24134.010.01

O'BRIEN & GERE
ENGINEERS INC.

Figure 2. *Example chain-of-custody*

Project Name:Support Sampling , Sauget Area 1 Site, Solutia Inc.
Job No. _____
Sheet ____ of ____

Office: _____
Address: _____
Phone: _____

CHAIN OF CUSTODY

Cooler Temperature _____

CLIENT: LOCATION:			COLLECTED BY: (Signature)				
SAMPLE DESCRIPTION/LOCATION	Date	Time	Sample Matrix[1]	Sample Type[2]	No. of Containers	ANALYSIS REQUESTED[3]	Sample Preservation

[1] Matrix = Ground water, surface water, sediment, biota [3] VOC - USEPA 8260, 8270, 6010 [2]Type = grab, composite

Relinquished by: _____ of: _____	Date	Time	Received by: _____ of: _____	Date	Time
Relinquished by: _____ of: _____	Date	Time	Received by: _____ of: _____	Date	Time
Relinquished by: _____ of: _____	Date	Time	Received by: _____ of: _____	Date	Time
Use this space if shipped via courier (e.g., Fed Ex) Relinquished by: _____ of: _____	Date	Time	Courier Name and Airbill Number: _____ _____ *Attach delivery/courier receipt to Chain of Custody	Date	Time
Relinquished by: _____ of: _____	Date	Time	Received by: _____ of: _____	Date	Time

Figure 3. *Example Laboratory Internal Chain of Custody Form*

ICP METALS SAMPLE CONTROL LOG

QC Batch #:

Date Digested:

Client/Job Number	Laboratory Sample Number Range	Laboratory Sample Numbers Removed	Removed by	Date Removed	Time Removed	Time Returned

Figure 4. Example sample label and tag

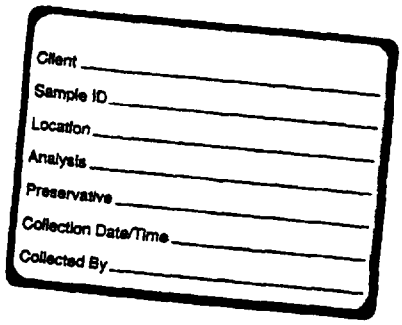
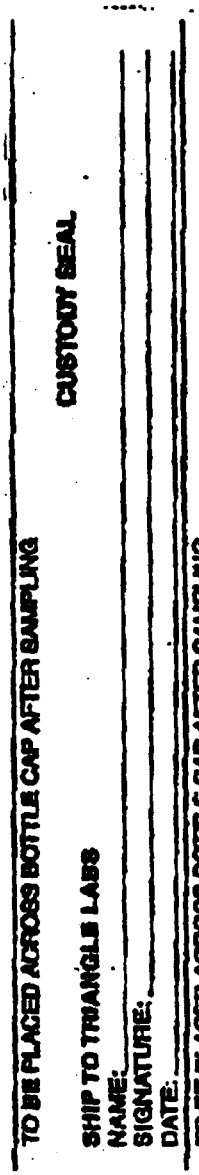


Figure 5. Example custody seal for Savannah Laboratories & Environmental Services, Inc.

Figure 6. Example custody seal for Triangle Laboratories, Inc.



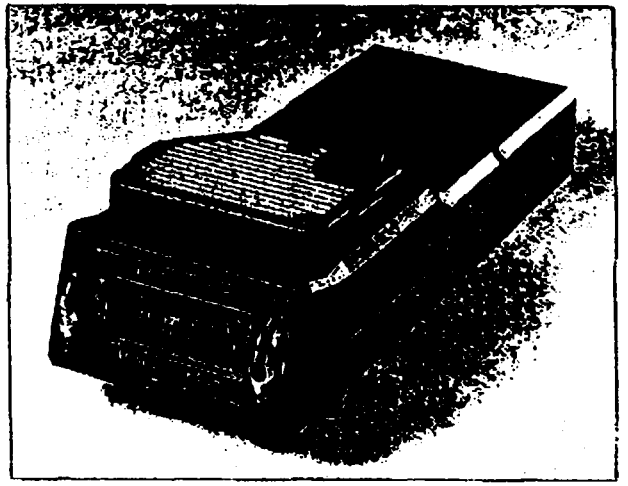
APPENDICES

Appendix C

Neotronics MiniGas 4 Portable 4-in-1 Multi-Gas Monitor calibration information of soil gas

MiniGas 4

MULTIPLE DISPLAY
PORTABLE 4 IN 1 MULTI-GAS MONITOR



REFERENCE MANUAL

NEOTRONICS

CHAPTER 6

CALIBRATING THE MINIGAS 4

CAUTION: The MiniGas 4 must be calibrated by authorised competent technicians using the correct equipment. If in doubt, or if the correct equipment is not available, then the instrument must be returned to Neotronics or an Authorised Distributor for calibration.

6.1 INTRODUCTION

The MiniGas 4 should be calibrated at intervals of not more than six months, or after repair. Instruments with the datalogging option have a programmed 'calibration due' date and when that date has expired an alarm occurs during the instrument start-up sequence (see Chapter 2, Section 2.4).

The procedures described in this chapter and Appendix C assume that the instrument is a fully equipped MiniGas 4. References to sensors not fitted in the instrument under test should be ignored.

6.1.1 Methods of calibration

With the current software version installed in MiniGas 4, two methods of calibration are available - easy calibration (referred to as 'EasyCal') and manual calibration. For the user, EasyCal is the recommended procedure and provides the following facilities:

- Simultaneous zeroing of all channels.
- Automatic detection of when calibration gas is applied.
- Simultaneous span calibration through the use of multigas cylinders.
- Automatic timing of the span gassing period.
- Automatic storage of the calibration results for future downloading via LogView.

The procedures described in this chapter are concerned only with EasyCal, but for the sake of completness a description of the full manual calibration procedure will be found in Appendix C. The only facility provided by the manual method that is not available with EasyCal is the adjustment of the explosive channel temperature and linearisation coefficients.

6.2 TOOLS AND TEST EQUIPMENT

The following items are required to calibrate any fully equipped MiniGas 4.

- Test gases contained in cylinders fitted with a low flow (300ml/min) gas regulator (Neotronics can supply suitable calibration kits - refer to Appendix B for part numbers):

  Methane - 1% to 1.5% VOL, or 20% to 30% LEL in air (NOT in nitrogen),

  Carbon monoxide - 350 to 600ppm in air or nitrogen,

  Hydrogen sulphide - 65 to 90ppm in nitrogen,

  Chlorine - 30ppm in nitrogen.

NOTE: As an alternative to individual test gas cylinders, it is permissible with EasyCal to use mixed test gases in the appropriate concentrations provided that the mixture does not contain gases inapplicable to the sensors fitted.

- Aspirator plate assembly (part no. 325-9374-00) (used as a calibration hood).
- 2mm A/F hexagonal wrench (Allen key).
- Gas tubing of suitable size and length for connecting the gas cylinder to the calibration hood.

NOTE: Tubing lengths should be kept to a minimum to reduce the effects of gas adsorption (see to Section 6.3.1).

6.3 PREPARATION FOR CALIBRATION

WARNING: THE TEST GASES ARE VENTED TO ATMOSPHERE DURING THE FOLLOWING PURGING AND CALIBRATION PROCEDURES. ENSURE ADEQUATE VENTILATION OR USE A FUME CUPBOARD.

Calibration must take place in a clean, fresh air environment at an ambient temperature of between 20° and 25°C (68° to 77°F).

Smoking or the use of butane lighters, solvents etc nearby can cause faulty, and hence potentially dangerous, calibration.

Ensure that the MiniGas is fitted with either a fully charged battery pack or a new set of dry cells.

NOTE: When gas is applied to the MiniGas, alarms may occur other than those associated with the gas being used. This is normal and is due to the composition of the test gas.

6.3.1 Adsorption of the test gas

Instead of passing freely along the gas tubing, molecules of the test gas can stick onto the tubing wall, thereby reducing the concentration of the gas at the end of the tubing. This effect is known as adsorption and is more noticeable with certain gases, particularly hydrogen sulphide and chlorine.

For example, when using 75ppm hydrogen sulphide in 5mm diameter neoprene tubing the reduction in gas concentration is approximately 1ppm/metre. That is, the concentration would be reduced to 70ppm at the end of a 5 metre length of tubing. If the inside of the tubing is wet, the adsorption effect on hydrogen sulphide is aggravated and the resulting reduction in concentration could be as high as 5 or 6ppm/metre.

WARNING: PTFE TUBING MUST BE USED FOR CHLORINE TEST GAS - RUBBER TUBING IS NOT SUITABLE.

If it is suspected that the tubing is wet, it should be dried by hanging vertically (with both ends pointing downwards) for at least 24 hours. DO NOT attempt to dry it with a compressed air supply as this may leave traces of silicone oil which can damage or affect the response of the MiniGas sensors.

6.3.2 Purging the gas connections

Before calibrating the explosive or toxic gas channels, the gas connections (Fig 6.1) must be thoroughly purged with the test gas or gas mixture.

(1) Connect the gas cylinder to the calibration hood using the shortest possible length of tubing, but do not fit the calibration hood to the instrument under test.

(2) Turn on the gas cylinder, ensuring that the flow regulator is set to 300ml/min.

(3) For all gases except chlorine, allow the test gas to purge the tubing and connections for two minutes. **For chlorine, purge for 30 minutes.**

(4) Turn off the gas cylinder.

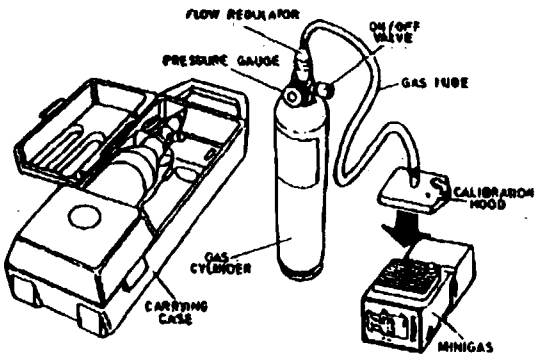


Fig 6.1 Gas calibration kit

6.4 CALIBRATION PROCEDURES

The following procedures include instructions to apply short, medium or long duration presses on the internal calibration button. In this context, 'short' is for a single bleep, 'medium' is for two bleeps and 'long' is for three bleeps.

Some of the prompt screens appearing on the MiniGas display during calibration present the operator with a yes/no option (*-y* or *n-*). Press the green button for 'Yes' or the red button for 'No'.

6.4.1 Entering Calibration Mode

All alarm conditions are cleared automatically when Calibration Mode is entered. However, this mode cannot be entered if a low battery warning condition exists.

(1) Switch on the MiniGas and select instantaneous (INST) display.

(2) Identify the calibration button anti-tamper screw at the top left of the instrument just to the rear of the sensor grill. Remove and retain the screw and washer (2mm A/F Allen key).

(3) Insert the long shaft of the Allen key through the screw hole and apply a short or medium press to the internal calibration button to enter EasyCal mode. Applying a long press to the button will cause the MiniGas to enter Manual Calibration Mode. In this event, escape by applying another long press to the button to return the instrument to instantaneous display.

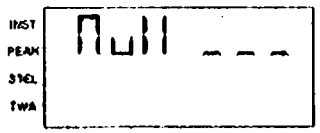
(4) Proceed with zero calibration.

6.4.2 Simultaneous zeroing

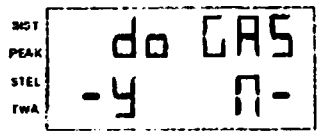
On entering Calibration Mode the ***Put Air*** screen is displayed. This is a prompt to put the MiniGas in a clean air environment. Take care not to breathe over, or near, the sensor grill while zero calibration is being performed.

(1) Select 'Yes' to perform zero calibration, or 'No' to abort calibration and return to the normal instantaneous display.

(2) While zero calibration is being performed, which takes less than 4 seconds, the ***Null*** screen is displayed. Toxic and explosive channels are calibrated to read 0 and the oxygen channel to read 20.9%.



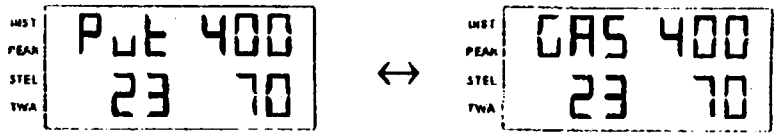
(3) When zeroing is complete the ***do GAS*** screen is displayed. This is a prompt to apply a calibration gas or gas mixture for any of the fitted sensor channels. If it was necessary only to zero the MiniGas readings, select 'No' to return to the normal instantaneous display. Otherwise, continue with span calibration.



6.4.3 Span calibration

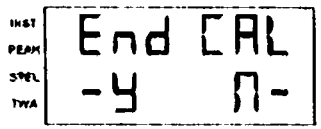
Before proceeding with span calibration, ensure that the gas connections have been purged as per the instructions given in Section 6.3.2.

(1) With the ***do GAS*** screen displayed, select 'Yes'. While waiting for the calibration gas, or gas mixture, to be applied the upper left section of the screen alternates between ***Put*** and ***GAS*** with the expected test gas concentrations displayed in the respective labelled positions.



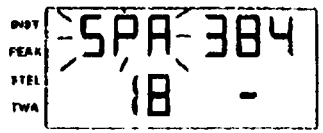
(2) If the known concentrations of the test gases about to be used differ from the expected values indicated on the ***Put ↔ GAS*** screens, then the expected concentrations must be changed as described in Section 6.6.

(3) If at this stage it is necessary to abort the calibration exercise, press the red button to obtain the ***End CAL*** screen and select 'Yes' to return to the normal instantaneous display. Otherwise, select 'No' to return to the ***Put ↔ GAS*** screens and continue with span calibration.

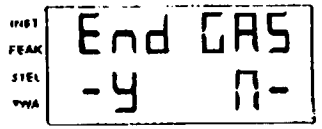


(4) Fit the calibration hood to the MiniGas and turn on the test gas cylinder.

From this point on, span calibration of the toxic and explosive channels is fully automatic and requires no adjustments or timing on the part of the operator. By monitoring the sensor outputs, the instrument software automatically detects when the gas has been applied and which gas type(s) it is. It then starts timing the gassing period. During this period, ***SPA*** is shown flashing in the upper left section of the screen with the instantaneous readings of the sensor(s) being gassed shown in their respective labelled positions. If a sensor channel is not being calibrated with the applied gas, a dash character appears in the appropriate position.

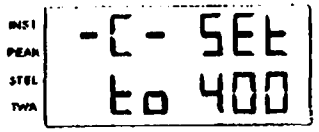


(5) If at this stage it is necessary to abort the gassing exercise, press the red button to obtain the ***End GAS*** screen. Then select 'Yes' to return to the ***Put ↔ GAS*** screens and turn off and disconnect the applied gas. Otherwise, select 'No' to return to the ***SPA*** 'gassing-in-progress' screen.



NOTE: The ***End GAS*** screen will time-out after 4 seconds and return to the 'gassing-in-progress' screen.

(6) When the MiniGas has been able to set the span for the respective channels, the screen indicates the sensor that has been calibrated and the gas concentration that it has been spanned to. For example, the following illustration shows the carbon monoxide channel having been spanned to 400ppm.



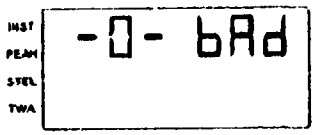
(7) Press the red or green button to accept the calibration and, if a multiple test gas has been used, step the screen through the other sensor(s) that have been calibrated.

(8) If there are other channels still to be calibrated, pressing either button returns the MiniGas to the ***Put ↔ GAS*** screens. In this case, repeat the above procedure from operation (4).

(9) Finally, when all channels have been calibrated successfully turn off the test gas and remove the calibration hood. Then, in addition to accepting the calibration, pressing either button returns the MiniGas to the normal instantaneous display. The reason for removing the test gas before accepting the calibration is that, otherwise, the MiniGas is liable to go into alarm condition and, with a datalogging instrument, record a false alarm report.

6.4.4 Calibration failure

In the event of the failure to zero the toxic and explosive channels or span the oxygen channel, or span the toxic and explosive channels, then after the relevant stage (zeroing or spanning) the MiniGas sounds an error bleep and a ***bAd*** screen is displayed. For example, the following illustration shows the oxygen channel having failed to span.



Press the red or green button to accept this screen. After warnings have been shown for all failed channels, the MiniGas returns to the normal instantaneous display.

With a toxic or explosive channel calibration failure, the test equipment should always be checked before rejecting the MiniGas as defective. For example:

- Check that the calibration hood is fitted correctly and there are no obvious leaks.
- Check that the correct gas or gas mixture is being used and the gas cylinder is not exhausted.
- Cylinders containing reactive gases (hydrogen sulphide or chlorine) have a limited shelf life due to some or all of the gas being absorbed into the cylinder walls. Check by using a new cylinder.

With an oxygen calibration failure, check for contamination of the atmosphere surrounding the instrument during the calibration procedure.

If there is a calibration failure, and having ensured that there is no obvious external cause, the sensor should be replaced. Instructions for replacing the oxygen sensor will be found in Chapter 4, Section 4.6.1, but reference will need to be made to the MiniGas 4 Service Manual for details of changing a pellistor or toxic sensor. Alternatively, the instrument can be returned to Neotronics or an Appointed Distributor for repair.

6.4.5 Storage of calibration results

After calibration, the MiniGas stores the following data about the calibration session for downloading via LogView at a later date:

- Date when calibration was performed.
- Which channels were calibrated and whether or not they passed.

6.5 POST CALIBRATION

On the successful completion of the calibration procedure(s):

(1) Switch off the MiniGas and disconnect all test equipment.

(2) Fit the calibration button anti-tamper screw and washer.

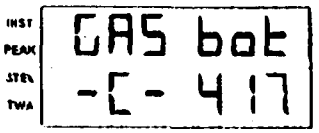
6.6 SETTING GAS BOTTLE CONCENTRATIONS

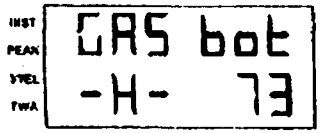
If, at the start of span calibration, it is noted that the test gas concentrations certified on the gas cylinders being used differ from the expected concentrations shown on the ***Put ↔ GAS*** screens, then the expected values must be reset as follows.

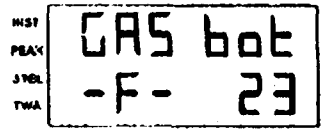
(1) With the ***Put ↔ GAS*** screens displayed, press the internal calibration button to obtain the first of the ***GAS bot*** screens.

(2) Adjust the expected concentration value, appearing in the lower right section of the screen, by means of the green (increase) and red (decrease) buttons until the screen reads the same as the value certified on the gas cylinder.

(3) Press the calibration button to step on to the next screen in the sequence and repeat the setting operation. As an example, the following illustrations show the sequence for carbon monoxide, hydrogen sulphide and explosive gases.







(4) Having set all channels to the appropriate expected test gas concentration, the final press on the calibration button returns the MiniGas to the ***Pul ↔ GAS*** screens.

(5) Continue with span calibration from operation (4) in Section 6.4.3.

APPENDIX A

SOFTWARE OPTIONS

The following programmable facilities can be configured into the MiniGas 4, either at the time of ordering the instrument or as a subsequent modification. However, certain options are incompatible with each other (for example, the AutoZero and Standby mode options are not available with Go/NoGo instruments).

A MiniGas 4 Questionnaire (part no. 006-0286-00) is available to assist Neotronics distributors and their customers in defining the MiniGas configuration (that is, software options, alarm levels etc) to suit particular user requirements.

NOTES: Modifying MiniGas instruments to change or add to the options can be carried out only by Neotronics, an Authorised Distributor or a user who has purchased an option to use Neotronics configuration software.

The ✓ column indicates standard options that are configured unless requested otherwise.

Option	Brief description	✓
Peak (low)	Display of the minimum oxygen measurement since switch on, or since the last peak reset. Available for oxygen channel only.	✓
Peak (high)	Display of the maximum measurement since switch-on, or since the last peak reset.	✓
STEL measurement	Display of the short term exposure calculation (not available for oxygen channel).	✓
TWA measurement	Display of the time weighted average calculation (not available for oxygen or explosive channel).	✓
Enable Warning Alarm Bleep	Explosive and toxic gas instantaneous first level (high) dual-tone alarms changed to a single-tone warning bleep (see Section 2.15.2).	
Disable Dual Tone Alarm Bleep	As the above Enable Warning Alarm Bleep but also with all other gas dual-tone alarms changed to single-tone (see Section 2.15.2).	
Alarm Jump	Under alarm conditions, the instrument immediately displays the appropriate measurement. If more than one alarm occurs, it shows the screen with the highest priority alarm.	✓

Appendix D

Static head space gas chromatography standard operating procedure (SOP)

STATIC HEADSPACE GAS CHROMATOGRAPHY

I. SCOPE AND APPLICATION

A. This method closely parallels EPA Method 3810 and is a static headspace technique for extracting volatile organic compounds (VOCs) from samples. It is a method that allows large numbers of samples to be screened in a relatively short period of time. Detection limits for this method may vary widely among samples because of the large variability and complicated matrices of waste samples. The method works best for compounds with boiling points of less than 125°C. The sensitivity of this method will depend on the equilibria of the various compounds between the vapor and dissolved phases.

B. Data generated by this method is ideal for characterizing the nature and extent of VOCs in soils and groundwaters.

II. SUMMARY OF METHOD

A. The sample is collected in a sealed glass container and allowed to equilibriate at 90°C. A sample of the headspace gas is withdrawn with a gas-tight syringe for analysis by gas chromatography (G.C.).

III. INTERFERENCES

A. Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. To reduce carryover, the sample syringe must be thoroughly cleaned between samples.

B. Before processing any samples, the analyst should demonstrate daily through the analysis of an organic-free water or solvent blank that the entire analytical system is interference-free.

IV. APPARATUS AND MATERIALS

A. Vials: 40 ml vials with open top screw caps and teflon/silicone septa.

B. Gas Chromatograph: Shimadzu GC-14A or equivalent lab-grade unit.

C. Data System: Shimadzu CR4A or equivalent.

D. Detectors: Flame ionization and/or electron capture.

E. Column: Restek 502.2, 624, or equivalent middle-polarity phase.

F. Syringes: Hamilton syringes including 10-μL and 500-μL gas-tight.

G. Heating block.

V. PROCEDURE

A. Gas chromatographic conditions and calibration.

1. The following conditions are provided as a guide; optimum performance will depend on analytes of interest:

   a. Oven Temperature Program: 70°C (5 min) → 10°C/min → 190°C (5 min)
   b. Injector Temp = 275°C
   c. Detector Temp = 290°C
   d. Carrier Gas = Nitrogen @ 19 ml/min (for 105m column)
   e. Injection Amount = 350μL
   f. Initial calibration should consist of at least three concentration levels for each target analyte.

B. Sample preparation and analysis.

1. Soil sample
   Place 20.0 g soil sample into a vial.
   Add 20.0 ml DI H_2O (shown to be free of contamination) to vial and soil.
   Shake for 1 minute.

   or

   Groundwater sample
   Place 20.0 ml groundwater sample into a vial.

2. Place sample vial in heating block at 90°C for 1 hour.

3. Withdraw 350 μL of the headspace with a gas-tight syringe and analyze by direct injection into the G.C.

VI. QUALITY CONTROL

A. A three (or five) point calibration curve must be set-up before samples are analyzed.

B. A method blank must be analyzed at the start of each day and at a rate of one per every 10 samples to show the system is interference-free.

C. A continuing calibration check must be analyzed at the start of each day and at a rate of one per every 10 samples to verify that the operation of the measurement system is in control and not varying.

Soil, Ground Water, Surface Water, Sediment, and Air Sampling
HEALTH AND SAFETY PLAN

Sauget Area 1
Support Sampling Plan
Sauget and Cahokia, Illinois
Volume 2C

Remediation Technology Group
Solutia Inc.
St. Louis, Missouri

June 1999

O'BRIEN & GERE
ENGINEERS, INC.

10040/23548

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June 1999

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1. Introduction

This Health and Safety Plan (HASP) has been developed to provide both general procedures and specific requirements to be followed by O'Brien & Gere Engineers, Inc. (O'Brien & Gere) personnel while performing sampling activities at Sauget Area 1, which is located along Dead Creek in the villages of Sauget and Cahokia, Illinois. Figure 1 is a site plan. This HASP describes the responsibilities, training requirements, protective equipment, and standard operating procedures to be used by O'Brien & Gere personnel to address potential health and safety hazards while performing sampling activities. O'Brien & Gere's Field Sampling Plan for the Sauget Area 1 Site dated June 1999 describes the sampling activities to be performed. This HASP specifies procedures and equipment to be used by O'Brien & Gere personnel during work activities and emergency response to minimize exposures of O'Brien & Gere personnel to hazardous materials.

1.1. Implementation of the HASP

The requirements and guidelines presented in this HASP are based on a review of available information and an evaluation of potential on-site hazards. This HASP incorporates by reference the applicable Occupational Safety and Health Administration (OSHA) requirements in 29 CFR Part 1910, 29 CFR Part 1926 and EPA Publication 9285.1-03. O'Brien & Gere personnel are required to read this HASP before beginning work on-site. This HASP will be available for inspection and review by O'Brien & Gere employees and contractor representatives while work activities are underway. When conducting the sampling activities listed in the Field Sampling Plan, O'Brien & Gere personnel will comply with this HASP. On-site O'Brien & Gere personnel will notify the O'Brien & Gere Site Safety and Health Coordinator (SSHC) of matters of health and safety. The SSHC is responsible to the Project Manager for monitoring activities, monitoring compliance with the provisions of this HASP, and for modifying this HASP to the extent necessary if site conditions change. This HASP is specifically intended for the conduct

of activities in the scope of work defined in the Field Sampling Plan and in the areas of the Sauget Area 1 Site specified for these work activities. Although this HASP can be made available to interested persons for informational purposes, O'Brien & Gere does not assume responsibility for the interpretations or activities of any persons or entities other than employees of O'Brien & Gere.

1.2. Project organization

Personnel involved in the activities at the Sauget Area 1 Site implicitly have a part in implementing the HASP. Among them, the Project Officer, the Project Manager, the Corporate Associate for Safety and Health, the SSHC, and the Field Leader have specifically designated responsibilities. Their names and telephone numbers are listed in Table 1-1. Other key O'Brien & Gere project personnel, the project's organization, and other primary contacts for the project are presented in the Field Sampling Plan.

Key project personnel and their responsibilities with regard to the Sauget Area 1 Field Sampling Plan are discussed below.

1.2.1. Project officer

Mr. Dean L. Palmer, PE, is the Project Officer. The Project Officer is responsible for the overall administration and technical execution of the project. The Project Officer is further responsible for the acquisition and delegation of resources necessary for project completion and HASP implementation.

1.2.2. Project manager

Mr. Alan J. Cork, PE, is the Project Manager. The Project Manager reports to the Project Officer and is directly responsible for the technical progress and financial control of the project.

1.2.3. Associate for safety and health

Mr. Saunders E. Wilson, CIH, CSP, is the Corporate Associate for Safety and Health. Mr. Wilson will be responsible for implementation of this HASP. Procedural changes and modifications to this HASP must be approved by Mr. Wilson.

1.2.4. Site safety and health coordinator

Mr. David E. Haverdink, or a designee, is the O'Brien & Gere Site Safety and Health Coordinator (SSHC) for this investigation. The SSHC for O'Brien & Gere employees reports to the O'Brien & Gere Project Manager, coordinates his activities with the O'Brien & Gere Associate for Safety and Health, establishes operating standards, and coordinates overall project safety and health activities for the site. The SSHC reviews project plans and revisions to plans to verify that safety and health procedures are maintained throughout the investigation. The SSHC audits the effectiveness of the HASP on a continuing basis and suggests changes, if necessary, to the Project Manager.

Specifically, the SSHC is responsible for the following actions:

- Providing a complete copy of the HASP at the site before the start of activities
- Familiarizing workers with the HASP
- Conducting on-site health and safety training and briefing sessions
- Documenting the availability, use, and maintenance of personal protective and other safety or health equipment
- Maintaining safety awareness among O'Brien & Gere employees on-site and communicating safety and health matters to them
- Reviewing field activities for performance in a manner consistent with O'Brien & Gere's policy and this HASP
- Monitoring health and safety conditions during field activities
- Coordinating with emergency response personnel and medical support facilities
- Notifying the Project Manager of the need to initiate corrective actions in the event of an emergency, an accident, or identification of a potentially unsafe condition
- Notifying the Project Manager of an emergency, an accident, the presence of a potentially unsafe condition, a health or safety problem encountered, or an exception to this HASP

- Recommending improvements in safety and health measures to the Project Manager
- Conducting safety and health performance and system audits.

The SSHC has the authority to recommend that the Project Manager take the following actions:

- Suspend field activities or otherwise limit exposures if the health or safety of any O'Brien & Gere employee appears to be endangered
- Notify O'Brien & Gere personnel to alter work practices that the SSHC deems to not protect them
- Suspend an O'Brien & Gere employee from field activities for violating the requirements of this HASP.

1.2.5. Field leader

Mr. David E. Haverdink, or a designee, will act as the Field Leader. The Field Leader will be responsible for overall site coordination including field sampling collection and chain-of-custody. The Field Leader will report directly to the Project Manager.

Table 1-1. *Project personnel.*

Name and title	Telephone
Dean L. Palmer, PE, Project Officer, St. Louis, MO	314-842-4550
Alan J. Cork, PE, Project Manager, St. Louis, MO	314-842-4550
Saunders E. Wilson, CIH, CSP, Associate for Safety and Health, Syracuse, NY	315-437-6100 315-420-0554
David E. Haverdink, Site Safety and Health Coordinator, St. Louis, MO	314-842-4550
David E. Haverdink, Field Leader, St. Louis, MO	314-842-4550

Source: O'Brien & Gere Engineers, Inc.

2. Hazard analysis

The tasks to be conducted in the sampling areas include:

- Trenching
- Soil gas sampling
- Magnetometer survey
- Installation of soil borings and collection of cuttings
- Installation of trenches and waste characterization
- Ground water sampling at existing wells
- Installation and sampling of ground water wells
- Domestic water sampling
- Surface and subsurface soil sampling
- Surface water and sediment sampling
- Air sampling.

The details of these tasks are presented in the Field Sampling Plan and will be conducted in accordance with the procedure outlined in the Field Sampling Plan. Both the potential health and safety hazards and the hazard and contaminant control procedures for each task are discussed below. Based on the available soil and water data, there is a potential for exposure to soil and water constituents as particulates or vapors above the OSHA-permissible exposure level (PEL). Skin contact with impacted soil and liquid should be minimized in accordance with good work practices.

Tables for establishing action levels for volatiles and non-volatiles for soil, ground water, and dust are presented as Appendix A. The action levels are based on prior soil and ground water analytical data reviewed by O'Brien & Gere.

Indicator compounds were identified, and action levels were developed based on the evaluation of potential exposures as identified in the tables in Appendix A. These tables were developed by a member of the Hazardous Waste Action Coalition and were presented at a Professional Development Course during the 1994 American Industrial Hygiene Conference and Exposition.

The tables in Appendix A were used to estimate the worst-case potential for release of the volatile and semi-volatile compounds identified as being present

in the soil and ground water of this site. The tables used the saturation vapor pressure and water solubility of these volatile and semi-volatile materials to estimate the potential levels of volatile and semi-volatile compounds that could be released at the surface of the soil or ground water.

The levels of volatile and semi-volatile compounds on the site vary with location. To approximate worst-case conditions, the levels used in this table are the maximum reported.

Due to dilution, the estimated airborne release levels are not expected to reach the breathing zones of site workers. Although the concentration of compounds will decrease with dilution, the proportions within the mix are assumed to remain constant. The proportion of the vapors reaching the breathing zone is thus expected to remain the same as that at the surface of the soil or the ground water.

The calculations assumed that all materials released had a proportional effect on an exposed employee. These levels were compared with published standards for a risk assessment, including a calculation of the allowable exposure to a mixture. Action levels and monitoring were based on these proportions, with the most easily identified compound, either by concentration or monitoring method, selected as the one of interest.

There is a potential for exposure to benzene, xylene, 1,2, dichloroethene, methylene chloride, and chlorobenzene as vapors released from the soils. Generic MSDSs for these materials are attached in Appendix B. A total organic vapor action level of 3.8 ppm has been established.

There is the potential to exposure from benzene, vinyl chloride, toluene, and 1,2 dichloroethene from the ground and/or surface water. Generic MSDSs for these materials are attached in Appendix B. A total organic vapor action level of 1.8 ppm has been established.

There is the potential for exposure to arsenic, barium, beryllium, copper, dioxin, lead, selenium, and vanadium in the dust generated during activities on the site. Generic MSDSs for these materials are attached in Appendix B. A total dust action level of 0.03 mg/m^3 has been established.

2.1. Trenching

Test trenches will be completed to delineate site boundaries and to uncover magnetic anomalies. Photos will be taken of the sides and bottoms of the trenches. Spoil from the trenches will be returned to the excavation in reverse order of removal. Maximum anticipated depth of the trenches is of 40 ft below grade. O'Brien & Gere employees will not enter the trenches. Whole drums encountered during the magnetic anomaly test trench completion will be removed from the trenches in accordance with the procedures described in section 2.11 of this HASP. A "competent person", as defined in 29 CFR 1926.650, will observe the trenching activities and will have authorization to take corrective measures to respond to unsanitary, hazardous, or dangerous conditions to workers.

2.1.1. Potential health hazards and hazardous constituents

During the trenching operations, there is the potential for the release of volatile organic material and contact with semi-volatile and particulate materials. There is the potential for the sides of the trench to cave in. The possibility exists for splashing of water onto the workers and release of volatile materials onto workers' bodies and into the workers' breathing zones. This may also cause a reduction in the oxygen level in the trench.

2.1.2. Hazard and hazardous constituent control

Initially, Level C personal protective equipment (PPE) will be worn while observing the trenching activities. Overalls or aprons will be worn when there is a need to handle or work with potentially impacted soil, wastes, or liquids.

Trenching will be conducted in accordance with the requirements of Subpart P of 29 CFR 1926 The trenches, while in use, will be inspected hourly by the Field Leader, with changing conditions noted and work modifications made. The sides of the trench will be sloped or a trench box will be used as necessary to minimize the potential for cave-ins. Material excavated from the trenches will be placed away from the edge of the trench to prevent cave-ins and minimize instability of the trench. During trench construction, air in the breathing zone of the workers will be sampled for volatile organic compounds (VOCs) using a photoionization detector (PID). Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

Measurement equipment will be decontaminated in accordance with the guidelines in O'Brien & Gere's Quality Assurance Program Plan (QAPP) dated June 1999 and in Chapter 8 of this HASP. Field decontamination wastes will be collected, drummed, and disposed in accordance with the procedures in the Field Sampling Plan.

2.2. Soil gas sampling

Soil gas samples will be collected to delineate the areal extent of VOC-containing soils at Sites G, H, I, L, and N.

2.2.1. Potential health hazards and hazardous constituents

There is the potential for contact with soil contaminants; the release of organic vapors from the subsurface soils; for musculoskeletal injuries when installing the soil gas probes and from bending to collect the samples; for back strain due to lifting probes and hammers and moving equipment; and the potential to get dirt in the eyes. Other hazards associated with soil gas sampling include slipping on wet, muddy surfaces created by spilled water and electrical hazards associated with the use of electrical equipment around water or wet surfaces.

VOCs may be present within and released from samples collected. The potential exists for release of these materials into the atmosphere at levels that may present an inhalation hazard. There is minimal potential for these levels to reach sustained explosive concentrations.

2.2.2. Hazard and hazardous constituent control

Level C PPE consisting of an air purifying respirator with organic vapor cartridges, a chemical resistant overall, leather steel-toed boots, nitrile gloves, and eye protection will be worn. Before initiating soil gas sampling, air in the general area will be checked with a PID and a CGM. Downgrading of respiratory protection and air monitoring activities will be in accordance with Chapter 6 of this HASP. Personnel must wear hearing protection when

working near operating heavy machinery and will remain upwind from vehicle exhaust.

A ground fault circuit interrupter will be used in the absence of properly grounded circuitry or when electrical equipment is used in wet conditions. Electrical extension cords used will be protected or guarded from damage and be maintained in good condition.

Back strain can be prevented by employing proper lifting and bailing techniques. Heavy equipment, such as pumps and generators, will only be lifted with the legs, preferably using two or three personnel. Slipping on wet surfaces will be minimized by placing purged water in drums for removal. Also, boots with good treads will be worn, and personnel will be reminded to remain alert of the area where they are walking to decrease the chance of slipping.

Equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP. Purged water and decontamination wastes will be collected, drummed, and disposed in accordance with the Field Sampling Plan.

2.3. Magnetometer survey

Magnetometer surveys will be conducted at Sites G, H, I, L, and N to identify anomalies indicative of drum disposal or buried tanks.

2.3.1. Potential health hazards and hazardous constituents

General hazards associated with a site walk-through and / or a magnetometer survey include exposure to irritant and toxic plants such as poison ivy and sticker bushes which may cause allergic reactions to personnel; surfaces covered with heavy vegetation and under growth that may create a tripping hazard; back strain due to carrying instruments; and native wildlife such as rodents, ticks, and snakes that present the possibility of insect bites and associated diseases such as Lyme disease. There may also be contact with chemical hazards due to disturbances of possibly impacted areas.

2.3.2. Hazard and hazardous constituent control

Modified Level D PPE will be worn. Personnel will carry the appropriate first aid for known allergic reactions. Personnel will be cautioned to remain alert and observe terrain while walking to minimize slips and falls. Proper lifting techniques will be used to prevent back strain. Personnel will be warned to avoid wildlife when possible. In case of an animal bite, personnel will perform first aid and capture the animal, if possible, for rabies testing. Personnel will perform a tick check after leaving a wooded or vegetated area.

To minimize exposure to volatiles during surface water and sediment sampling, air in the breathing zone of the sampler will be sampled for VOCs using a PID. Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

To minimize contact with irritant and toxic plants and to protect against insect bites, Level D protection will include long sleeve shirts and slacks.

Measurement equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP.

2.4. Installation of soil borings and collection of cuttings

Soil borings will be performed to identify the limit of the work areas and to identify subsurface materials. The soil samples from the borings will be collected, examined, and prepared for shipment. Cuttings will be containerized and transferred to the central solid waste disposal container.

2.4.1. Potential health hazards and hazardous constituents

Hazards generally associated with drilling operations include noise levels exceeding the OSHA PEL of 90 dBA that are both a hazard and a hindrance to communication, carbon monoxide from the drill rig, and overhead electrical and telephone wires which can be hazardous when the drill rig boom is in the upright position. Moving parts on the drill rig may catch clothing. Free or falling parts from the cat head may cause head injury. Moving the drill rig

over uneven terrain may cause the vehicle to roll over or get stuck in a rut or mud. High pressure hydraulic lines and air lines used on drill rigs are hazardous when they are in disrepair or incorrectly assembled. There may be underground utilities in the area where drilling is being performed.

During the retrieval of augers and during the piling of cuttings, the possibility exists for splashing of exposed subsurface materials onto the workers and release of dust and volatile materials onto workers' bodies and into the workers' breathing zones.

There is the potential for combustible gases to be released during the soil borings. Other hazards generally encountered during soil boring and sample collection include exposure to vapors and contact with hazardous materials. Volatile organic vapors may be released from the cuttings.

2.4.2. Hazard and hazardous constituent control

Personnel must wear hard hats and ear muffs and/or ear plugs when working near operating heavy machinery. Initially, Level C PPE will be worn. Chemical-resistant overalls will be worn during drilling and when there is a need to handle or work with potentially impacted soil or liquid. Loose clothing will be secured and the boom position will be checked prior to approaching the drill rig.

O'Brien & Gere personnel will remain upwind from the vehicle exhausts unless required by sampling work. During drilling, if wet methods are not used, air in the breathing zone of the worker will be sampled for respirable dust using a real time aerosol monitor (RAM) at approximately five-minute intervals. Air will be sampled for volatile organic vapors using a PID at approximately five-minute intervals. Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

A ground fault interrupter will be used in the absence of properly grounded circuitry or when pumps are used around wet conditions. Electrical extension cords will be protected or guarded from damage and be maintained in good condition. The drilling subcontractor will be required to inspect chains, lines, cables, and high-pressure lines daily for weak spots, frays, and other signs of wear. The drilling subcontractor will be required to make repairs as necessary. To avoid contact with overhead lines, the drilling subcontractor will be required to lower the drill rig boom prior to moving the rig. The drilling subcontractor will be required to verify the location of underground utilities with both the facility and the local power and utility companies prior to

drilling. Overhead and underground utilities will be considered "live" until verified otherwise.

To minimize exposure to volatiles during sample collection, a PID will be placed near the sample to monitor levels of volatile organic vapors. A CGM will be used to determine if there are elevated concentrations of explosive gases or vapors. Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

Equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP. Cuttings and decontamination wastes will be collected, drummed, and disposed in accordance with the Field Sampling Plan.

2.5. Ground water sampling at existing wells

Existing ground water monitoring wells will be purged and samples collected.

2 5.1. Potential health hazards and hazardous constituents

There is the potential for combustible gases to accumulate in an existing monitoring well. Other hazards generally encountered during ground water purging and sampling include exposure to vapors. Volatile organic vapors may have accumulated in the wells and may be present when the well head is initially opened.

2.5.2. Hazard and hazardous constituent control

Initially, Level C PPE with organic vapor cartridges will be worn. Chemical-resistant overalls or aprons will be worn when there is a need to handle or work with potentially impacted liquid.

To measure exposure to volatiles when the well head is opened, a PID will be placed near the opening to monitor levels of volatile organic vapors.

Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

To measure exposure to volatiles during well purging, air in the breathing zone of the worker will be sampled for VOCs using a PID. A CGM will be used to determine if there are elevated concentrations of explosive gases or vapors. Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

A ground fault interrupter will be used in the absence of properly grounded circuitry or when pumps are used around wet conditions. Electrical extension cords will be protected or guarded from damage and be maintained in good condition.

Equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP. Cuttings and decontamination wastes will be collected, drummed, and disposed in accordance with the Field Sampling Plan.

2.6. Installation and sampling of ground water wells

Ground water monitoring wells will be installed and developed and samples collected.

2.6.1. Potential health hazards and hazardous constituents

Hazards generally associated with drilling operations include noise levels exceeding the OSHA PEL of 90 dBA that are both a hazard and a hindrance to communication, carbon monoxide from the drill rig, and overhead electrical and telephone wires which can be hazardous when the drill rig boom is in the upright position. Moving parts on the drill rig may catch clothing. Free or falling parts from the cat head may cause head injury. Moving the drill rig over uneven terrain may cause the vehicle to roll over or get stuck in a rut or mud. High pressure hydraulic lines and air lines used on drill rigs are hazardous when they are in disrepair or incorrectly assembled. There may be underground utilities in the area where drilling is being performed.

During the retrieval of augers, the possibility exists for splashing of exposed subsurface materials onto the workers and release of dust and volatile materials onto workers' bodies and into the workers' breathing zones.

There is the potential for combustible gases to be released during the installation of new monitoring wells. Other hazards generally encountered during well installation and ground water sampling include exposure to vapors and contact with hazardous materials.. Volatile organic vapors may have accumulated in the wells.

2.6.2. Hazard and hazardous constituent control

Personnel must wear hard hats and ear muffs and/or ear plugs when working near operating heavy machinery. Initially, Level C PPE will be worn. Coveralls will be worn during drilling and when there is a need to handle or work with potentially impacted soil or liquid. Loose clothing will be secured and the boom position will be checked prior to approaching the drill rig.

O'Brien & Gere personnel will remain upwind from the vehicle exhausts unless required by sampling work. During drilling, if wet methods are not used, air in the breathing zone of the worker will be sampled for respirable dust using a RAM at approximately five-minute intervals. Air will be sampled for volatile organic vapors using a PID at approximately five-minute intervals. Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

A ground fault interrupter will be used in the absence of properly grounded circuitry or when pumps are used around wet conditions. Electrical extension cords will be protected or guarded from damage and be maintained in good condition. The drilling subcontractor will be required to inspect chains, lines, cables, and high-pressure lines daily for weak spots, frays, and other signs of wear. The drilling subcontractor will be required to make repairs as necessary. To avoid contact with overhead lines, the drilling subcontractor will be required to lower the drill rig boom prior to moving the rig. The drilling subcontractor will be required to verify the location of underground utilities with both the facility and the local power and utility companies prior to drilling. Overhead and underground utilities will be considered "live" until verified otherwise.

To minimize exposure to volatiles during purging and sampling, a PID will be placed near the opening to monitor levels of volatile organic vapors. A CGM will be used to determine if there are elevated concentrations of explosive gases or vapors. Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

Equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP. Cuttings and decontamination wastes will be collected, drummed, and disposed in accordance with the Field Sampling Plan.

2.7. Domestic water sampling

Water from domestic wells will be collected.

2.7.1. Potential health hazards and hazardous constituents

There is minimal potential for contact with impacted water and for the inhalation of volatile organics during the collection of domestic water.

2.7.2. Hazard and hazardous constituent control

Level D PPE will be worn. Air will be sampled for volatile organic vapors using a PID at approximately five-minute intervals. Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

A ground fault circuit interrupter will be used in the absence of properly grounded circuitry or when electrical equipment is used in wet conditions. Electrical extension cords used will be protected or guarded from damage and will be maintained in good condition.

Equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP. Purged water and decontamination wastes will be collected, drummed, and disposed in accordance with the Field Sampling Plan.

2.8. Surface and subsurface soil sampling

Soil samples will be collected from the first 6 inches of the surface and from 0.5 to 6 ft below the surface.

2.8.1. Potential health hazards and hazardous constituents

There is the potential for contact with soil contaminants, the release of organic vapors from the subsurface soil samples, for musculoskeletal injuries when using the soil augers and bending to collect the samples, and the potential to get dirt in the eyes. Other hazards associated with soil sampling include slipping on wet, muddy surfaces created by spilled water and electrical hazards associated with the use of electrical equipment around water or wet surfaces.

2.8.2. Hazard and hazardous constituent control

Modified Level D PPE, consisting of work clothes, leather steel-toed boots, gloves, and eye protection, will be worn. Because of the potential for exposure to dioxin in Area G, Level C with a least a P100 respirator filter will be worn during sampling in this area. Before initiating soil sampling, air in the general area will be checked with a PID. Respiratory protection and air monitoring activities will be in accordance with Chapter 6 of this HASP. Personnel must wear hearing protection when working near operating heavy machinery and will remain upwind from vehicle exhaust.

A ground fault circuit interrupter will be used in the absence of properly grounded circuitry or when electrical equipment is used in wet conditions. Electrical extension cords used will be protected or guarded from damage and be maintained in good condition.

Back strain can be prevented by employing proper lifting and bailing techniques. Heavy equipment, such as pumps and generators, will only be lifted with the legs, preferably using two or three personnel.

Equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP. Purged water and decontamination

wastes will be collected, drummed, and disposed in accordance with the Field Sampling Plan.

2.9. Surface water and sediment sampling

Surface water and sediment samples will be collected using laboratory-provided sample containers and stainless steel spoons, respectively.

2.9.1. Potential health hazards and hazardous constituents

During the collection of the surface water and sediment samples, the possibility exists for the splashing of samples onto the workers and the release of volatile materials onto workers' bodies and into the workers' breathing zones. There is also the potential for falling into the water of the creek or the borrow pit lake.

2.9.2. Hazard and hazardous constituent control

Modified Level D PPE, including chemical resistant overalls or aprons, will be worn because of the need to handle or work with potentially impacted liquid.

To minimize exposure to volatiles during surface water and sediment sampling, air in the breathing zone of the sampler will be sampled for VOCs using a PID. Subsequent monitoring and respirator wear will be in accordance with Chapter 6 of this HASP.

A personal flotation device will be worn by each worker during surface water sampling in water more than 24 inches deep. A throwable flotation device with at least 90 ft of floating solid braid (polypropylene or equivalent) rope will be on the shore for use if a worker falls into the water or slips down the shore. A pole or other line will be available on the shore to assist in retrieving workers that have fallen into the water.

Measurement equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP. Cuttings and field

decontamination wastes will be collected, drummed, and disposed in accordance with the Field Sampling Plan.

2.10. Air sampling

Samples of ambient air surrounding the site will be collected to evaluate the tendency for site constituents to enter the atmosphere and local wind patterns.

2.10.1. Potential health hazards and hazardous constituents

There is the potential for musculoskeletal injuries when installing the ambient air samplers and from reaching to collect the samples. There is also the potential to get dirt in the eyes. Other hazards associated with air sampling include slipping on wet, muddy surfaces and electrical hazards associated with the use of electrical equipment around water or wet surfaces.

VOCs may be present in the area from which the samples are collected. The potential exists for release of these materials into the atmosphere at levels that may present an inhalation hazard.

2.10.2. Hazard and hazardous constituent control

Level D PPE, consisting of a coverall, leather steel-toed boots, gloves, and eye protection, will be worn. Before initiating air sampling, air in the general area will be checked with a PID. Respiratory protection and air monitoring activities will be in accordance with Chapter 6 of this HASP. Personnel must wear hearing protection when working near operating heavy machinery and will remain upwind from vehicle exhaust.

A ground fault circuit interrupter will be used in the absence of properly grounded circuitry or when electrical equipment is used in wet conditions. Electrical extension cords used will be protected or guarded from damage and be maintained in good condition.

Back strain can be prevented by employing proper lifting techniques. Heavy equipment, such as pumps and generators, will only be lifted with the legs, preferably using two or three personnel. Boots with good treads will be worn, and personnel will be reminded to remain alert of the area where they are walking to decrease the chance of slipping.

Equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP.

2.11. Removing drums and other material from trenches

While performing test trenches to investigate magnetic anomalies, whole drums may be removed from the trenches and overpacked.

2.11.1. Potential health hazards and hazardous constituents

Drums containing potentially hazardous materials may be removed from trenches. The possibility exists for splashing material onto the workers and the release of dust and volatile materials onto workers' bodies and into the workers' breathing zones. These materials, if encountered, may be spread through the air and through skin contact with impacted soil and water. Back strain and muscle fatigue due to lifting, shoveling, and auguring techniques are possible. There is the potential for combustible gases to be released during the drum removal.

During the excavation process, the backhoe may slide or sink, causing possible injuries to on-site employees. The sides of the excavation can cave in due to 1) absence of shoring, 2) misjudgement of stability, 3) defective shoring, and/or 4) undercut sides. The cave-in may result in possible burying or crushing of workers Workers can fall during access/egress or while monitoring or dismounting equipment, or can stumble into the excavation. An overhead hazard can result from material, tools, rock, and/or soil falling into the excavation.

The work area may become congested due to too many workers being present in a small area. During the removal, there is the potential for rupture of the drum and the release of its contents onto the soil and into the air.

2.11.2. Hazard and hazardous constituent control

Initial PPE when removing drums will be Level B for the removal personnel and Modified Level D for O'Brien & Gere employees. The air in the work area will be monitored continuously during removal activities using a PID and a RAM. Subsequent monitor and respirator wear will be in accordance with Chapter 6 of this HASP. O'Brien & Gere personnel will remain at least 5 ft clear from the removal activities and will not enter the trenches. Personnel must wear hearing protection and hard hats when working near operating heavy machinery.

Warning tape will be placed around the work areas to restrict entrance during the drum excavation process and prevent the spread of contaminants which may be encountered. A barrier around the open pits will be provided.

The contractor removing the drum will provide overpack drums and trained employees to perform the drum removal. Drum handling procedures must meet the requirements of 29 CFR 1910.120(j).

Material excavated from each pit will be placed away from the edge of the pit to prevent cave-ins and minimize instability of the pit. Shoring or sloping of sides of the excavation in accordance with 29 CFR 1926.650-652 will be provided.

The Field Leader will maintain ample work room between the workers. Manual lifting will be limited to prevent overexertion, and mechanical means will be used where practical.

Equipment will be decontaminated in accordance with the guidelines in the QAPP and in Chapter 8 of this HASP.

3. Personnel training

3.1. Site workers

O'Brien & Gere employees performing the activities listed in the Field Sampling Plan must have completed a training course of at least 40 hours meeting the requirements of 29 CFR 1910.120(e) for safety and health at hazardous waste operations. If the course was completed more than 12 months before the date of site work, completion of an approved 8-hr refresher course on health and safety at hazardous waste operations is required.

O'Brien & Gere employees must comply with the O'Brien & Gere Quality Assurance Manual. The respiratory protection program is specified in Section 004.2 of Vol 3. The Hazard Communication Program is specified in Section 003 of Vol 3. The Audit Program is specified in Section 019 of Vol 3. The Confined Spaces Entry Program is specified in Section 008 of Vol 3.

3.2. Management and leaders

In addition to the requirements described in section 3.1 for O'Brien & Gere site workers, O'Brien & Gere field leaders must have completed an off-site training course of at least 8 hours meeting the requirements of 29 CFR 1910.120(e) on supervisor responsibilities for safety and health at hazardous waste operations.

3.3. Emergency response personnel

O'Brien & Gere employees who respond as "Good Samaritans" to emergency situations involving health and safety hazards must be trained in how to respond to such emergencies in accordance with the provisions of 29 CFR 1910.120(l). Skills such as cardiopulmonary resuscitation (CPR), mouth-to-mouth rescue breathing, avoidance of blood-borne pathogens, and basic first aid skills may be necessary.

3.4. Site-specific training

Site-specific training will be provided to each O'Brien & Gere employee and reviewed before assignment. O'Brien & Gere personnel will be briefed daily by the Field Leader or by the SSHC as to the potential hazards that may be encountered during that day. Topics will include:

- Availability of this HASP
- General site hazards and specific hazards in the work areas
- Selection, use, testing, and care of the body, eye, hand, foot, and respiratory protective equipment being worn and the limitations of each
- Decontamination procedures for O'Brien & Gere personnel, their personal protective equipment, and other equipment used on-site
- Emergency response procedures and requirements
- Emergency notification procedures and evacuation routes to be followed
- Procedures for obtaining emergency assistance and medical attention.

3.5. Training certification

A record of employee training completion will be maintained by the SSHC for each O'Brien & Gere employee who is trained. This record will include the dates of the completion of worker training, supervisor training, refresher training, emergency response training, and site-specific training for on-site O'Brien & Gere employees.

4. Personnel protection

The basic level of PPE to be used during activities at the Sauget Area 1 Site is a modification of OSHA Level D. PPE may be upgraded based on air monitoring results or at the discretion of the Project Manager and based on the SSHC's recommendations. A downgrade of PPE must be approved by the SSHC and the Project Manager.

If the SSHC verifies that field measurements or observations indicate that a potential exposure is greater than the protection afforded by the equipment or procedures specified in this or other sections of this HASP, the work will be stopped, and O'Brien & Gere personnel will be removed from the site until the exposure has been reduced or the level of protection has been increased.

O'Brien & Gere respirator users have been trained and medically approved to use respiratory protection. Respirators issued are approved for protection against dust and organic vapors by NIOSH. Respirators are issued for the exclusive use of one worker and will be cleaned and disinfected after each use by the worker. Respirator users must check the fit of the respirator before each day's use to see that it seals properly. The respirator must seal against the face so that the wearer receives air only through the air purifying cartridges attached to the respirator. No facial hair that interferes with the effectiveness of a respirator will be permitted on personnel required to wear respiratory PPE. Cartridges and filters for air-purifying respirators in use will be changed daily at a minimum. The user will inspect the integrity of air-purifying respirators daily.

4.1. Protective equipment description

The level of PPE is categorized as Level A, B, C, or D, based upon the degree of protection required. The following is a brief summary of the three levels that may be used on this site.

4.1.1. Level B

The concentration(s) and type(s) of airborne substance(s) is unknown and the criteria for not using a totally encapsulating suit are met. The following constitute Level B equipment:

- NIOSH-approved, positive pressure, full-face air supplying respirator or self contained breathing apparatus.
- Chemical-resistant clothing with hood [chemical-splash suit, disposable chemical-resistant overalls (sarenax-coated Tyvek® or equivalent)]
- Coveralls (optional)
- Gloves, outer, chemical-resistant (neoprene)
- Gloves, inner, chemical-resistant (neoprene or latex)
- Boots, outer, leather, with steel toe and shank
- Chemical resistant boot covers (neoprene or butyl rubber)
- Hard hat (Class B)
- Personal flotation device with rope when sampling in water greater than 24 inches deep
- Hearing protection when working in noise hazardous areas, as defined in O'Brien & Gere's Quality Assurance Manual.

4.1.2. Level C

The concentration(s) and type(s) of airborne substance(s) is known and the criteria for using air purifying respirators are met. The following constitute Level C equipment:

- NIOSH-approved, full-face air purifying respirator with organic vapor cartridges and P100 particulate filters
- Chemical-resistant clothing with hood [chemical-splash suit, disposable chemical-resistant overalls (polyethylene coated Tyvek® or equivalent)]
- Coveralls (optional)
- Gloves, outer, chemical-resistant (neoprene)
- Gloves, inner, chemical-resistant (neoprene or latex)
- Boots, outer, leather, with steel toe and shank
- Optional chemical resistant boot covers (neoprene or butyl rubber)
- Hard hat (Class B)
- Personal flotation device with rope when sampling in water greater than 24 inches deep
- Face shield and safety glasses when not wearing a full face respirator.

- Hearing protection when working in noise hazardous areas, as defined in O'Brien & Gere's Quality Assurance Manual.

4.1.3. Modified Level D

The concentration(s) and type(s) of airborne substance(s) is known and the criteria for not using air purifying respirators are met. A level of skin protection above Level D is required. The following constitute Modified Level D equipment:

- Chemical-resistant clothing [chemical-splash suit, disposable chemical-resistant overalls (polyethylene coated Tyvek® or equivalent)]
- Coveralls (optional)
- Gloves, outer, chemical-resistant (neoprene)
- Gloves, inner, chemical-resistant (neoprene or latex)
- Boots, outer, leather, with steel toe and shank
- Optional chemical resistant boot covers (neoprene or butyl rubber)
- Hard hat (Class B)
- Personal flotation device with rope when sampling in water greater than 24 inches deep
- Face shield and safety glasses
- Hearing protection when working in noise hazardous areas, as defined in O'Brien & Gere's Quality Assurance Manual.

4.1.4. Level D

A work uniform affording minimal protection, used for nuisance contamination only. The following constitute Level D equipment:

- Coveralls (cloth)
- Apron (plastic) for splash protection as necessary
- Gloves (neoprene or leather)
- Boots or shoes, leather, steel toe and shank
- Optional chemical resistant boot covers (neoprene or butyl rubber)
- Safety glasses or chemical splash goggles
- Hard hat (Class B)
- Personal flotation device with rope when sampling in water greater than 24 inches deep
- Escape mask (optional)
- Face shield when not wearing other eye protection.

- Hearing protection when working in noise hazardous areas, as defined in O'Brien & Gere's Quality Assurance Manual.

4.2. Protective equipment selection

Initial levels of PPE will be as shown in the following table

Activity	Level B	Level C	Modified Level D	Level D
Trenching		Observation		
Soil Gas Sampling		Initial		
Magnetometer Survey			Initial	
Installation of soil borings and collection of cuttings		Initial		
Ground water sampling at existing wells		Initial		
Installation and sampling of ground water wells		Initial		
Domestic Water Sampling				Initial
Surface and subsurface soil sampling		Area G	Initial	
Surface water and sediment sampling			Initial	
Air sampling				Initial

4.3. Protective equipment failure

If an individual experiences a failure or other alteration of PPE that may affect its protective ability, that person is to leave the work area immediately. The Project Manager or the SSHC must be notified and, after reviewing the situation, is to evaluate the effect of the failure on the continuation of on-going operations. If the Project Manager or the SSHC ascertains that the failure affects the safety of workers, the work site, or the surrounding environment, workers are to be evacuated until corrective actions have been taken. The SSHC will not allow re-entry until the equipment has been repaired or replaced and the cause of the failure has been identified.

5. Medical monitoring

5.1. Medical surveillance program

O'Brien & Gere has implemented a medical monitoring program in accordance with 29 CFR 1910.120. The O'Brien & Gere program is designed to monitor and reduce health risks to employees potentially exposed to hazardous materials and to provide baseline medical data for each employee involved in work activities. It is also designed to evaluate the employee's ability to wear PPE such as chemical-resistant clothing and respirators.

Medical examinations are administered on a post-hire and annual basis and as warranted by symptoms of exposure or specialized activities. The post-hire examination provides baseline data. The examining physician is required to make a report to O'Brien & Gere of any medical condition that would increase the employee's risk when wearing a respirator or other PPE. O'Brien & Gere maintains site personnel medical records as required by 29 CFR 1910.120 and by 29 CFR 1910.1020, as applicable.

O'Brien & Gere employees performing the activities listed in the Field Sampling Plan or this document have or will receive medical tests as regulated by 29 CFR 1910.120. Where medical requirements of 29 CFR 1910.120 overlap those of 29 CFR 1910.134 or 29 CFR 1910.1025, the more stringent standard will be enforced.

5.2. Respirator certification

Employees who wear or may wear respiratory protection have been provided respirators as required by 29 CFR 1910.134. This standard requires that an individual's ability to wear respiratory protection be medically certified before performing designated duties.

6. Air monitoring

There is the potential for hazardous materials to be present at the Sauget Area 1 Site at levels that will pose a health hazard to workers. Real time monitoring of organic vapors will be conducted on-site by, or under the supervision of the SSHC, to evaluate the concentrations of organic vapors and site-generated dusts. An action level of 3 ppm has been selected based on the potential for exposure to benzene (PEL 1 ppm) released as a soil vapor or from the ground water. A dust action level of 0.03 mg/m^3 has been selected for protection from exposure to vanadium, arsenic, beryllium, and lead. The SSHC will evaluate whether the personal protective measures employed during field activities are appropriate and will modify the protective measures accordingly. Field personnel will record equipment calibrations, repairs, and readings in a notebook that is a part of the site log. The SSHC will be responsible to maintain monitoring instruments throughout the investigation.

6.1. Field instrumentation and calibration

On-site air monitoring at the Sauget Area 1 Site will include the use of a photoionization detector (PID), and a real time aerosol monitor (RAM).

6.1.1. Photoionization detector (PID)

Hazard monitored. Many organic and some inorganic gases and vapors.

Application. Detects the presence and total concentration of many organic and some inorganic gases and vapors.

Detection method. Ionizes molecules using ultra-violet (UV) radiation; produces a current that is proportional to the number of ions present.

General care and maintenance. Recharge daily or replace the battery. Regularly clean the lamp window. Regularly clean and maintain the instrument and its accessories. Turn the function switch to "stand-by" and

allow the instrument to "warm up" for 5 minutes. Calibrate once a day using an isobutylene gas standard according to the manufacturer's instructions. Repeat the procedure to validate calibration.

Typical operating time. 10 hours; 5 hours with strip chart recorder.

6.1.2. Real time aerosol monitor (RAM)

Hazard monitored. Particulates. A RAM will be employed for on-site measurement of the total dust concentration.

Application. Measures total or respirable particulates in air.

Detection method. Uses an internal light source. The particulates bend the light beam, and the amount of diffraction is converted into concentration (mg/m^3).

General care and maintenance. Recharge the batteries daily. Replace the desiccant when necessary. Check, in accordance with the manufacturer's instructions, for appropriate responses prior to each use.

Typical operating time. 8-12 hours..

6.1.3. Combustible Gas Monitor (CGM)

Hazard monitored. Combustible gases and vapors.

Application. Measures the concentration of combustible gases or vapors.

Detection method. One method uses a filament, usually made of platinum, that is heated by burning the combustible gas or vapor. The increase in heat is measured. Another method ionizes gases and vapors in a flame. A current is produced in proportion to the number of carbon atoms present.

General care and maintenance. Recharge daily or replace the battery. Calibrate immediately before use.

Typical operating time. 10 to 12 hours on one battery charge.

6.2. Air sampling

The air will be monitored with a portable PID to assess the presence and concentration of organic vapor during drilling and sampling activities. The air will be monitored with a RAM during drilling activities to asses the level of airborne dusts. The air will be monitored with a combustible gas monitor during intrusive work to detect the presence of combustible concentrations of materials. Samples will be collected in the breathing zone and, if O'Brien & Gere workers are wearing respiratory protective equipment, outside the face piece. The sampling strategies described below may change if work tasks or operations change. Monitoring instruments will be checked for appropriate response, in accordance with the manufacturer's instructions, before use each sampling day.

6.2.1. PID monitoring

The air will be monitored with a portable PID equipped with a 10.2 or 11.7 electron volt detector, as appropriate, to assess the presence and concentration of VOCs. Ionization potential tables are included in Appendix A for reference. Samples will be collected continuously in the breathing zone of the O'Brien & Gere worker at approximately five-minute intervals. The PID will be checked for positive and accurate response to a pre-established concentration of isobutylene in accordance with the manufacturer's instructions before use each sampling day.

Before the start of work, the PID will be used to assess the concentration of VOCs upwind from the work area. When VOC levels exceed the action level, the PID will be used to measure the VOC level downwind from the work area.

6.2.2. RAM monitoring

Air monitoring with a portable RAM will be performed to assess the presence and concentration of respirable dust during activities on the site. During drilling, if wet methods are not used, sampling in the breathing zone of the geologist during drilling will be performed at approximately five-minute intervals. The RAM will be checked, in accordance with the manufacturer's operating instructions, prior to use each sampling day for appropriate responses.

6.2.3. CGM monitoring

The air will be monitored continuously with a CGM during intrusive activities to assess the presence and concentration of combustible gases and vapors. The CGM will be programmed to sound an alarm when the combustible gas concentration exceeds 20% of the lower explosive limit (LEL) for methane. During trench entry, the CGM will be programmed to respond at 10% of the LEL. The CGM will be checked for appropriate response, in accordance with the manufacturer's instructions, before use each sampling day.

6.3. Quality control - field sampling

The SSHC, or someone under the direct supervision of the SSHC, will collect health and safety samples. Bound log books and appropriate data sheets will be used to document the collection of samples and data so that an individual data set can be traced to its point of origin, the sampler, and the sampling equipment used. Sampling will be performed according to the manufacturer's instructions.

6.4. Action levels

Action levels are used to ascertain when activities should stop, to ascertain when site evacuation is necessary, to select emergency response levels, and to change PPE levels.

6.4.1. Organic vapors

Organic vapors may be liberated from the ground water or from the soil during site activities. A PID will be used to assess the presence of total organic vapors.

There is a potential for exposure to benzene, xylene, 1,2, dichloroethene, methylene chloride, and chlorobenzene as vapors released from the soils. Generic MSDSs for these materials are attached in Appendix B. A total organic vapor action level of 3.8 ppm has been established.

There is the potential to exposure from benzene, vinyl chloride, toluene, and 1,2 dichloroethene from the ground and/or surface water. Generic MSDSs for these materials are attached in Appendix B. A total organic vapor action level of 1.8 ppm has been established.

Actions, such as increasing ventilation, will be implemented to promote dispersion of the vapors if present. Work will cease at any time that the reading on the PID exceeds 1.8 ppm during water sampling or 3.8 ppm during soil and sediment sampling. Air purifying respirators and chemical resistant clothing will be donned by on-site employees at these times. Work may resume and continue until the measured VOC concentration is greater than or equal to 35 ppm. At that time, the workers will leave that work area. Actions, such as increasing ventilation, will be implemented to promote dispersion of the vapors. Following work area evacuation, a minimum of two workers in Level B PPE will be required to re-enter the work area to assess the organic vapor levels in the work area and determine if the work area can be re-entered by others. Workers with respirators may re-enter the area when the PID reading is less than 15 ppm.

The organic vapor level will be measured upwind and downwind from the work location, at approximately thirty minute intervals, whenever air purifying respirators are being worn. If the downwind concentration exceeds the upwind concentration by more than 10 ppm, work on the site will stop until the downwind concentration is less than 10 ppm greater than the upwind concentration.

6.4.2. Particulates

There is the potential for exposure to arsenic, barium, beryllium, copper, dioxin, lead, selenium and vanadium in the dust generated during activities on the site. Generic MSDS for these materials are attached in Appendix B. A total dust action level of 0.03 mg/m^3 (30 μg/m^3) has been established.

The RAM will be used to measure particulates. When respirable particulates are detected at 30 μg/m^3 or greater, a full-face respirator with P100 filters will be worn. Employees will leave the work area when the respirable dust concentration exceeds 1000 μg/m^3 and may not return until it is less than 750

$\mu g/m^3$. Following work area evacuation, a minimum of two workers in Level B PPE will be required to re-enter the work area to assess the particulate levels in the work area and determine if the work area can be re-entered by others. At dust concentrations that exceed 150 $\mu g/m^3$ above background, dust suppression techniques (*e.g.*, water application and activity controls) will be implemented to reduce the generation of dust.

Upon visual observation of air-borne particulate matter associated with on-site activities, a water spray will be applied as a control measure. If a water spray cannot be applied, additional personal monitoring will be undertaken to assess whether correct personal protective measures are being taken..

6.4.3. Combustible gases

Explosive levels of gases and vapors may accumulate in wellheads and low locations on the site. A CGM will be used during intrusive work to assess the level of combustible gas. An action level of 20% of the LEL for methane will be used for work outside of trenches. An action level of 10% of the LEL will be used inside of trenches. Work will cease at any location where the explosive gas reading exceeds the action level. Actions, such as increasing ventilation, will be taken to disperse the combustible gas from that area. If the combustible gas level does not decrease within 10 minutes, the SSHC will contact the Cahokia and Sauget Fire Department for assistance. Although personnel are not required to vacate the area until the LEL reaches the action level (10% or 20%), they may not return until the LEL is below 5% or 15%, respectively.

7. Site control

7.1. Site security

Site security will be monitored and controlled by the Project Manager, the Field Leader, and the SSHC. Their duties will include limiting access to the work area to authorized personnel, maintaining a sign-in roster, overseeing project equipment and materials, and overseeing work activities. The procedures specified below will be followed to control access to each work site to prevent persons who may be unaware of site conditions from exposure to hazards. Work area control procedures may be modified as required by activity and site conditions. Site security will be established on a site- and activity-specific basis.

7.2. Site control

An exclusion zone and a contamination reduction zone will be established by the SSHC at each sampling and drilling point. The remainder of the Sauget Area 1 Site will be the support zone. A map depicting the exclusion zone, contamination reduction zone, and support zone will be prepared and posted in the support zone. The layout of the zones, the procedures to be followed for zone control, and the signs used to indicate the zones will be reviewed during the daily safety briefings before beginning the day's work. The general area of the zones for each day will be identified by the SSHC and the Field Leader during the daily site briefing. This information will be included in the daily site log.

7.2.1. Exclusion zone

The exclusion zone is where sampling and observation of drilling activities are conducted. The SSHC will identify this zone. It must be at least 30 ft in

diameter and centered, when possible, on the work activities. This zone will be designated with red flags attached to portable stakes or cones installed before beginning the field work. The zone may be enlarged to contain the necessary ancillary equipment and personnel for the work to be done.

7.2.2. Contamination reduction zone

The contamination reduction zone (CRZ) contains personnel and equipment decontamination stations. The CRZ will be located upwind from the work activities. It will only be large enough to contain equipment and personnel necessary to keep potentially impacted media and materials in the immediate work area. This area will be designated with yellow flags attached to portable stakes or cones. The CRZ will be established on the day site work commences within a particular exclusion zone, based on the direction of the wind on that day.

7.2.3. Support zone

The remainder of the Sauget Area 1 area is defined as the support zone. The support zone contains support facilities, extra equipment, transport vehicles, and additional personnel and equipment necessary to manage and perform work activities.

7.3. Site access procedures

O'Brien and Gere personnel will sign in and out of Sauget Area 1 and in and out of each zone. O'Brien & Gere personnel leaving an exclusion zone will be decontaminated in a contamination reduction zone before entering the support zone. The Project Manager and the SSHC will establish decontamination locations for each site.

7.4. Site communications

A cellular telephone will be used during activities to facilitate communications for emergency response and other purposes and to serve as the primary off-site communication network. Telephones located at the Sauget Area 1 Site will provide back-up for the portable phones.

7.5. Confined space entry

Entry of permit-required confined spaces may occur during this project. O'Brien & Gere personnel will follow the procedures in Volume 3 of the O'Brien & Gere Engineers Quality Assurance Manual when such entry is necessary.

8. Decontamination

8.1. Personnel decontamination procedures

Sampling activities will occur in widely separated locations. For this reason, equipment and personnel decontamination will be done at each sampling area, using temporary facilities. The SSHC will be responsible for supervising the proper use and decontamination of equipment and PPE. The SSHC will also establish and monitor each decontamination line.

Decontamination involves scrubbing with a soap and water solution followed by rinses with potable water. Decontamination will take place on a decontamination pad. Dirt, oil, grease, or other foreign materials that are visible will be removed from surfaces. Scrubbing with a brush may be required to remove materials that adhere to the surfaces. Splash protection garments will be washed with soap and potable water before removal. Non-disposable garments will be air-dried before storage. Waste waters from personnel decontamination will be disposed of with the waste waters from equipment decontamination. Respirators will be sanitized as well as decontaminated each day before re-use. The manufacturer's instructions will be followed to sanitize the respirator masks.

The following decontamination protocol, or one providing the same level of decontamination, will be followed:

8.1.1. Station 1: equipment drop

Provide a table covered with a plastic drop cloth. Deposit equipment used on-site, including tools, sampling devices and containers, monitoring instruments, radios, and clipboards, on the table.

8.1.2. Station 2: outer garment, boots, and gloves wash and rinse
Establish a wash station for gloves, boots, and the protective suit (when worn). Scrub outer boots, outer gloves, and protective suit with detergent and water. Rinse with potable water.

8.1.3. Station 3a: outer boot and glove removal
Provide seating for use during the removal and collection of outer boots. Remove outer boots. Deposit them in a container with a plastic liner. If the boots are to be reused after cleaning, place them in a secure location near the work site. Provide a location for removal, collection, and disposal of outer gloves. Remove the outer gloves. Deposit them in a container for disposal. During hot weather, a cool-down station with chairs, fans, and replenishing beverages may be set up in this area.

8.1.4. Station 3b: filter or cartridge exchange
This station will be established only if respirators are worn. The workers' respirator cartridges and filters can be exchanged, new outer gloves and outer boots donned, and joints taped at this station. From here the worker can return to work duties in the exclusion zone.

8.1.5. Station 4: outer garment removal
This station will only be provided if a protective outer garment is worn. Provide a bench to sit on during the removal of the protective garment. If the garment is disposable, deposit it in a container with a plastic liner; otherwise, hang it up to air dry.

8.1.6. Station 5: respirator removal
This station will be established only if respirators are worn. Remove the respirator. Avoid touching the face with gloved fingers. Deposit the respirator on a plastic sheet.

8.1.7. Station 6: inner glove removal

Remove and dispose of inner gloves. Deposit them in a container with a plastic liner. If the gloves are to reused, place them in a secure location near the work site, preferably in a plastic container.

8.1.8. Station 7: field wash

Provide a place for a field wash. Wash hands and face thoroughly. Shower if body contamination is suspected.

8.2. Monitoring equipment decontamination procedures

Sampling equipment used for health monitoring purposes will be cleaned of visible contamination and debris before initial use on-site, between uses, and after final use. Monitoring equipment that contacts impacted media will be decontaminated after each use by a low-phosphate detergent brushing followed by a clean water rinse. After decontamination, monitoring equipment will be stored separately from PPE. Decontaminated or clean equipment not in use will be covered with plastic and stored in a designated storage area in the support zone.

8.3. Decontamination supplies

The following supplies will be available on-site as needed for the decontamination of personnel and equipment:

- Plastic drop cloths
- DOT-approved fiberboard drums to collect non-reusable protective clothing
- Plastic wash tubs
- Soft bristled long-handle brushes
- DOT-approved drums in which to collect wash and rinse water
- Hand spray units for decontamination
- Soap, water, alcohol wipes, and towels to wash hands, faces, and respirators
- Washable tables and benches or chairs.

8.4. Collection and disposition of impacted materials and refuse

Cuttings, purge waters, and field decontamination wastes will be collected at the point of generation and stored in temporary containers. PPE, solids, and liquids will be consolidated in separate bulk containers at a central area designated by Solutia. Solutia will be responsible for disposal of these materials.

9. Emergency response

9.1. Notification of site emergencies

In an emergency, site personnel will signal distress either verbally or with three blasts from a horn (vehicle horn, air horn, and so forth). The SSHC, Field Leader, or the Project Manager will immediately be notified of the nature and extent of the emergency.

Table 9-1 contains emergency telephone numbers. This table will be kept with the portable telephone and updated as needed by the SSHC. The portable telephone will be used to notify off-site personnel of emergencies. The operating condition of this telephone will be verified daily before initiation of activities.

Table 9-1. *Emergency telephone numbers.*

Location		Telephone
Fire Department	Emergency	911
	Sauget	618-332-6700
	Cahokia	618-337-5080
Police Department	Emergency	911
	Sauget	618-332-6507 or 6997
	Cahokia	618-337-9505
Ambulance	Emergency	911
Poison Control Center		1-800-942-5969
St. Mary's Hospital of East St. Louis, IL		618-274-1900
Chemical Emergency Advice (Client is O'Brien & Gere Engineers)		1-800-424-9300
James Rozier, Industrial Medical Associates Medical Director Contact		1-315-478-1977
National Spill Response Center		1-800-424-8802
USEPA, Region V, Chicago, IL (Michael McAteer)		312-886-4663
Solutia Inc. (Bruce Yare)		312-674-6370

Source: O'Brien & Gere Engineers, Inc.

A map showing the location and the route to St. Mary's Hospital is included as Exhibit A. Directions to St. Mary's Hospital from the site are as follows:

> From the Sauget Area 1 Site, drive west on Queeny Avenue to Illinois State Route 3, North (IL 3 N). Drive north on IL 3 N. Take the I 70 east/I 64 East/I 55 North exit toward Chicago/Indianapolis. Take the 4th St Exit toward Business District/East St. Louis. Merge onto south 4th Street, turn right onto east Broadway/IL 15. Turn left onto north 8th Street. St. Mary's Hospital is located at 129 North 8th Street. The distance from the site to the hospital is approximately three miles. The estimated driving time is seven minutes.

A copy of this HASP will be provided, through the community relations staff for this project, to St. Mary's Hospital and to the Cahokia and Sauget Fire and Police departments by the SSHC. Should someone be transported to a

hospital or doctor other than at St. Mary's Hospital, a copy of this HASP should accompany him/her.

9.2. Responsibilities

The SSHC is responsible for responding to, or coordinating the response of off-site personnel to, emergencies. In the event of an emergency, the SSHC will direct notification and response, and will assist the Field Leader in arranging follow-up actions. Upon notification of an exposure incident, the SSHC will call 911 and request that hospital, fire, and police emergency response personnel as necessary recommend medical diagnosis, treatment if necessary, and provide transportation to the hospital. The Field Leader will contact local, state, and federal government agencies, as appropriate.

Before the start of remedial action activities at the Sauget Area 1 Site, the SSHC will:

1. Notify emergency contacts, and health care facilities of the potentially hazardous activities on-site as a result of the activities listed in the Field Sampling Plan.

2. Confirm that the following safety equipment is available: eyewash and safety shower station, first aid supplies, air horn, fire extinguisher, and personal flotation device with a life line.

3. Have a working knowledge of the O'Brien & Gere safety equipment.

4. Confirm that a map detailing the most direct route to St. Mary's Hospital (Exhibit A) is prominently posted with the emergency telephone numbers (Table 9-1).

5. Confirm that employees who will respond to emergencies have been appropriately trained.

6. Collect and maintain a file of Material Safety Data Sheets (MSDS) for materials used at the site during the remedial action activities.

Before work may resume following an emergency, used emergency equipment must be recharged, refilled, or replaced and government agencies must be notified as required.

The Project Manager, assisted by the SSHC and the Field Leader, must investigate the incident as soon as possible. The Project Manager will assess whether and to what extent exposure actually occurred, the cause of exposure, and the means to prevent similar incidents. The resulting report must be signed and dated by the Project Manager, SSHC, and the Field Leader.

9.3. Accidents and injuries

In the event of an accident or injury, workers will immediately implement emergency isolation measures to assist those who have been injured or exposed and to protect others from hazards. Upon notification of an exposure incident, the SSHC will contact emergency response personnel who can provide medical diagnosis and treatment. If necessary, immediate medical care will be provided by personnel trained in first aid procedures. Other on-site medical or first aid response to an injury or illness will be provided only by personnel competent in such matters.

9.4. Safe refuge

Before commencing site activities, a place of refuge for O'Brien & Gere workers will be identified by the SSHC. For the purpose of this HASP, a location on the east side of Falling Springs Road will be selected as the place of safe refuge during a site evacuation. In case of an emergency, personnel in the exclusion zone should evacuate the work area both for their own safety and to prevent hampering rescue efforts. Following an evacuation, the SSHC will account for site personnel. If evacuation from the on-site refuge location is necessary, the project vehicles will be used to transport personnel to the place of refuge.

9.5. Fire fighting procedures

A fire extinguisher meeting the requirements of 29 CFR Part 1910 Subpart L, as a minimum, will be available in the support zone during on-site activities. This is intended to control small fires. When a fire cannot be controlled with the extinguisher, the exclusion zone will be evacuated, and the fire department will be contacted immediately. The SSHC or the Field Leader will decide when to contact the fire department.

9.6. Emergency equipment

The following equipment, selected based on potential site hazards, will be maintained in the support zone for safety and emergency response purposes:

- Fire extinguisher
- First aid kit
- Eye wash bottles.

9.7. Emergency site communications

Hand and verbal signals will be used at the Sauget Area 1 Site for emergency communications.

9.8. Security and control

Work zone security and control during emergencies, accidents, and incidents will be monitored by the SSHC or the Field Leader. The duties of the SSHC or the Field Leader include limiting access to the work zones to authorized personnel and overseeing emergency response activities.

10. Special precautions and procedures

The activities listed in the Field Sampling Plan may expose personnel to both chemical and physical hazards. The hazards associated with specific site activities are discussed in Chapter 2. The potential for exposure to hazardous situations will be significantly reduced through the use of air monitoring, PPE, hazard awareness, training, and administrative and engineering controls. Other general hazards that may be present on a hazardous waste work site are discussed below.

10.1. Heat stress

The timing and location of this project may be such that heat stress could pose a threat to the health and safety of site personnel. The SSHC will have a dry bulb thermometer on site and use it to implement work and rest regimens so that O'Brien & Gere personnel do not suffer adverse effects from heat. These regimens will be developed by the SSHC following the guidelines in Table 8-10 of the USEPA *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* which is attached in Appendix C. Special clothing and an appropriate diet and fluid intake will be recommended to O'Brien & Gere personnel involved in the activities specified in Chapter 2 to further reduce this hazard. In addition, ice and fluids will be provided as appropriate in the support zone.

10.2. Heavy machinery/equipment

O'Brien & Gere employees performing site activities may use or work near operating heavy equipment and machinery. Respiratory protection, hearing protection, and protective eyewear may be worn during portions of work activities. Since this protective equipment narrows the visual and acoustic environment of the wearer, O'Brien & Gere personnel should exercise extreme

caution in the vicinity of operating equipment and machinery to avoid physical injury to themselves or others.

10.3. Additional safety practices

The following are important safety precautions that will be enforced during the completion of the activities listed in Chapter 2:

1. O'Brien & Gere will not conduct operations during severe weather. The Field Leader and the SSHC will decide when severe weather conditions exist or are forecast and take actions appropriate to the site and the anticipated severe weather to minimize the potential exposure of O'Brien & Gere employees.

2. O'Brien & Gere employees will refrain from unnecessary contact with plants, animals, and other biological hazards on the site. Should contact occur, the employee must report it to the Field Leader, the SSHC, and the Corporate Associate for Safety and Health, following the procedures in Vol 3 of the O'Brien & Gere Quality Assurance Manual, Sections 001 and 017.

3. Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in the exclusion zone and contamination reduction zones.

4. Hands and face must be thoroughly washed when leaving the support zone and before eating or drinking.

5. Contact with potentially impacted surfaces should be avoided whenever possible. Workers should minimize walking through puddles, mud, or other discolored surfaces; kneeling on ground; and leaning, sitting, or placing equipment on drums, containers, vehicles, or the ground.

6. Medicine and alcohol can mask the effects of exposure to certain compounds. Consumption of prescribed drugs must be at the direction of a physician.

7. O'Brien & Gere personnel and equipment in the work areas will be minimized consistent with effective site operations.

8. Unsafe or inoperable equipment left unattended will be identified by a "DANGER, DO NOT OPERATE" tag.

9. Activities in the exclusion zone will be conducted using the "Buddy System." The Buddy is another worker fully dressed in the appropriate PPE who can perform the following activities:

   - Provide partner with assistance
   - Observe partner for sign of chemical or heat exposure
   - Periodically check the integrity of partner's PPE
   - Notify others if emergency help is needed.

8. The HASP will be reviewed frequently for its applicability to the current and upcoming operations and activities.

10.4. Daily log contents

The Project Manager and the SSHC will establish a system appropriate to the Sauget Area 1 Site that will record, at a minimum, the following information:

1. O'Brien & Gere personnel and other personnel conducting the site activities, their arrival and departure times, and their destination at the site

2. Incidents and unusual activities that occur on the site such as, but not limited to, accidents, breaches of security, injuries, equipment failures, and weather related problems

3. Changes to the Field Sampling Plan and the HASP

4. Daily information such as:

   - Work accomplished and the current site status
   - Air monitoring equipment calibrations, repairs, and results.
   - Site work zones.

References

American Conference of Governmental Industrial Hygienists 1998, *1998 TLV's® and BEIs,® Threshold Limit Values for Chemical Substances and Physical Agents, Biological Exposure Indices,* Cincinnati, OH

Marlowe, Christopher CIH. Camp Dresser & McKee, May 1994. "Action Levels for Hazardous Waste Site Work."

NIOSH, OSHA, USCG, EPA Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, DHHS (NIOSH) Publication No. 85-115. October 1985

O'Brien & Gere Engineers, Inc. 1999. *Field Sampling Plan, Sauget Area 1 Support Sampling Project, Sauget and Cahokia, Illinois, Volume 2.*

O'Brien & Gere Engineers, Inc. 1999. *Quality Assurance Project Plan, Sauget Area 1 Support Sampling Project, Sauget and Cahokia, Illinois, Volume 2.*

United States Environmental Protection Agency, *Health and Safety Plan (HASP) Users Guide,* Publication EPA 9285.8-01, July 1993

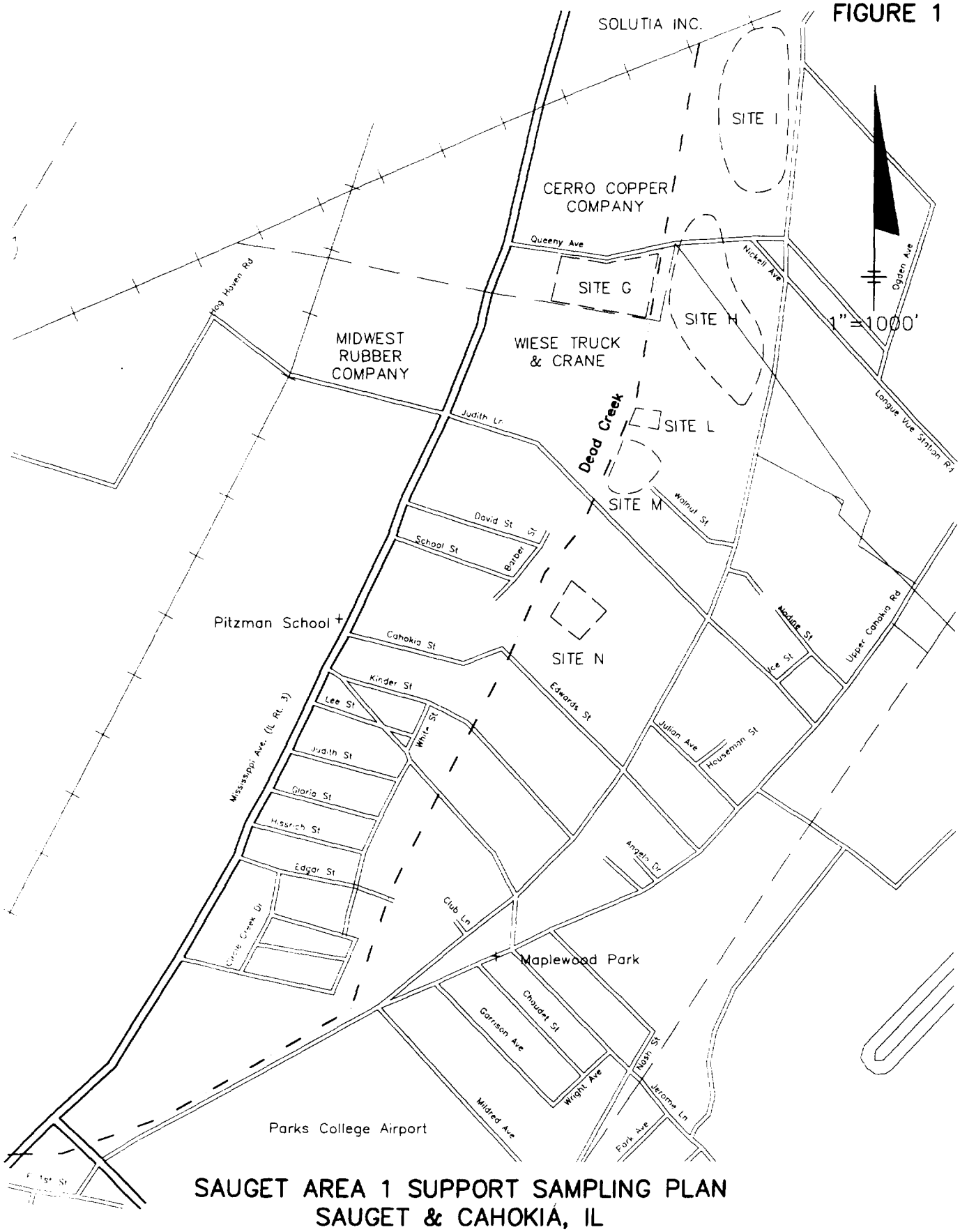
United States Environmental Protection Agency, *Standard Operating Safety Guides,* Publication EPA 9285.1-03, June 1992

29 CFR 1910.120 Hazardous Waste Operations and Emergency Response

29 CFR 1910.146 Permit-Required Confined Spaces

FIGURES

FIGURE 1



SAUGET AREA 1 SUPPORT SAMPLING PLAN
SAUGET & CAHOKIA, IL

SITE LOCATION MAP

23548.010.14
4/5/99

O'BRIEN & GERE ENGINEERS INC.

PLOT DATE: 4/5/99

APPENDICES

Soil, ground water, and dust action levels and ionization potential tables

Sauget Support (ORST CASE" VAPOR EXPOSURE CALCULATION
Sampling for volatile compounds in soil Carbon in Soil (frxn) 0 02

PARAMETER / CONTAMINANT	MAXIMUM CONCENTR'N in site soil (mg/Kg)	Water Solubility mg/l	Vapor Pressure (torr)	Partition Coefishent Koc (fraxion)	Exposure Limit (OSHA) (ppm)	Sat'n vapor Pressure* (ppm)	Fraction of Total vapor in Air (percent)	Saturation Concentr'n in Air % of PEL	Name of Chemical	1/ppm	ppm	Corrected for PID Calibrated to Benzene		Corrected for PID Calibrated to Benzene Add high #s for @min	Corrected for PID Calibrated to Isobutylene Add high #s for @min
Acetone	0.82	3000000	180	0 23	750	14 1	0 05%	1 88%	Acetone	0 00%	1 56E+06	9.84E+05	Acetone	1.00E+10	1 43E+10
Acrylonitrile	1E-09	79000	100	0 85	2	9 80E-08	0 00%	0 00%	Acrylonitrile	0 00%	5 98E+11	5 98E+11		1 00E+10	1 43E+10
Benzene	61.3	600	95	83	1	7691 6	26.25%	769158 06%	Benzene	26 25%	3.81	3.81	Benzene	3.81	5.44
Bromochloromethane	0 58	10000	300	13	200	8 80E+01	0 30%	44 02%	Bromochloromethane	0 00%	6 66E+04			1 00E+10	
Carbon Disulfide	0 0963	2000	300	54	4	17 59	0 06%	439 87%	Carbon Disulfide	0 02%	6 66E+03	9.38E-01	Carbon Disulfide	1 00E+10	1 43E+10
Carbon tetrachloride	0.035	800	91	110	2	2 38E+00	0 01%	119 03%	Tetrachloromethane	0 00%	2 46E+04			1 00E+10	
Chlorobenzene	539	500	11.8	330	10	2535 41	8 65%	25354 07%	Chlorobenzene	0 87%	115.57	115.57	Chlorobenzene	115.57	1 65E+02
Chloroform	20.2	7950	246	31	2	1326 23	4 53%	66311 45%	Trichloromethane	2 26%	44.19				
Dibromochloromethane	6 9	4700	50	50	1	96 56	0 33%	9656 33%	Chlorodibromomethane	0 33%	303.44	0.00E+00			
Dichlorobenzenes	1E-09	156	1 47	1700	75	0 0	0 00%	0 00%	Dichlorobenzene	0 00%	6 03E+15	7 84E+15	Dichlorobenzenes	1 00E+10	1 43E+10
1,1-Dichloroethane	1 6	5060	227	30	100	157 37	0 54%	157 37%	1,1-Dichloroethane	0 01%	1 86E+04	0 00E+00	1,1-Dichloroethane	1 00E+10	1 43E+10
1,2-Dichloroethane	0 435	8524	90	14	10	2 16E+01	0 07%	215 78%	1,2-Dichloroethane	0 01%	1 36E+04	0 00E+00	1,2-Dichloroethane	1 00E+10	1 43E+10
1,1-Dichloroethene	1E-09	2500	591	65	1	2 39E-07	0 00%	0 00%	Vinylidene chloride	0 00%	1 22E+11	8 57E+10	1,1-Dichloroethene	1 00E+10	1 43E+10
1,2-Dichloroethene	15	800	200	59	200	4180 61	14.27%	2090 31%	1,2-Dichloroethene	0 07%	1 40E+03	9 81E+02	1,2-Dichloroethene	9 81E+02	1 40E+03
1,4-Dioxane	1E-09	2000000	30	3 5	25	2 82E-10	0 00%	0 00%	1,4-Dioxane	0 00%	2 60E+15	2 60E+15	1,4-Dioxane	1 00E+10	1 43E+10
Ethyl Benzene	80	150	7.1	1100	100	226 43	0 77%	226 43%	Ethyl Benzene	0 01%	1 29E+04	1 50E+04	Ethylbenzene	1 00E+10	1 43E+10
Ethyl Chloride	1E-09	5740	900	11	1000	9 38E-07	0 00%	0 00%	Ethyl Chloride	0 00%	3 13E+13	0.00E+00	Ethyl Chloride	1 00E+10	1 43E+10
Formaldehyde	1E-09	400000	10	3 6	0 3	4 57E-10	0 00%	0 00%	Formaldehyde	0 00%	1 92E+13			1 00E+10	1 43E+10
Methyl Butyl Ketone	1E-09	5000000	3 8	9 8	5	5 10E-12	0 00%	0 00%	Methyl Butyl Ketone	0 00%	2 87E+16	1 49E+16	Methyl Butyl Ketone	1 00E+10	1 43E+10
Methyl Chloride	1E-09	4800	3756	35	50	1 47E-06	0 00%	0 00%	Chloromethane	0 00%	9 96E+11	0.00E+00	Methyl Chloride	1 00E+10	1 43E+10
Methyl Ethyl Ketone	14	3560000	100	4 5	200	5 75E+00	0 02%	2 87%	Methyl Ethyl Ketone	0 00%	1 02E+06	5.81E+05	Methyl Ethyl Ketone	1 00E+10	1 43E+10
Methylene Chloride	10	13000	435	8 8	50	2501 06	8 54%	5002 12%	Dichloromethane	0 17%	585.78		Methylene Chloride		
Naphthalene	1240	31.7	0 082	400	10	107.9	0 37%	1078 71%	Naphthalene	0 04%	2 72E+03	5 35E+03	Naphthalene	5 35E+03	7 64E+03
Nitrobenzene	1E-09	1900	0.15	33	1	0 0	0 00%	0 00%	Nitrobenzene	0 00%	1 86E+14	0.00E+00		1 00E+10	1 43E+10
Phenol	5708 15	87000	0 2	14.2	5	6 08E+01	0 21%	1215 65%	Phenol						
Styrene	1E-09	300	7	365	50	4.20E-09	0 00%	0 00%	Styrene	0 00%	3 48E+14	3 38E+14	Styrene	1 00E+10	1 43E+10
Tetrachloroethane	0 581	2900	7	118	1	7 82E-01	0 00%	78 17%	Tetrachloroethane	0 00%	3 75E+04	0 00E+00	Tetrachloroethane	1 00E+10	1 43E+10
Tetrachloroethylene	58.6	150 3	18 49	364	25	1302 67	4 45%	5210 69%	Perchloroethylene	0 18%	562.33	4.22E+02	Tetrachloroethylene	4 22E+02	6 03E+02
Toluene	118	500	25	300	50	1293 58	4 41%	2587 15%	Toluene	0 09%	1 13E+03	1 13E+03	Toluene	1 13E+03	1 62E+03
Triethylamine	1E-09	15000	54	11 3	1	2 10E-08	0 00%	0 00%	Triethylamine	0 00%	1 40E+12	1 24E+12		1 00E+10	1 43E+10
1,1,1-Trichloroethane	1 69	4400	124	152	350	2 06E+01	0 07%	5 89%	Methyl Chloroform	0 00%	4 98E+05	2 49E+05		1 00E+10	1 43E+10
Trichloroethylene	3 85	1100	75	126	50	137 03	0 47%	274 06%	Trichloroethene	0 01%	1 07E+04	9 52E+03	Trichloroethylene	1 00E+10	1 43E+10
Vinyl Chloride	1E-09	1100	760	57	1	7 97E-07	0 00%	0 00%	Vinyl Chloride	0 00%	3 68E+10	1 84E+10	Vinyl Chloride	1 00E+10	1 43E+10
Xylene	540	130	6.6	240	100	7513 53	25.64%	7513 53%	Xylene	0 26%	389.98	436.78	Xylene	4 37E+02	6 24E+02
											3.81			3.81	5.44
			Combined Volatile Level (ppm)			29,301 52	100 00%							Action level for total vapor based on cmpd closest to its PEL, including PID response, calibrated to Benzene	
			Fraction of Combined Exposure Limit					8,967 43	Times Limit for Exposure						

"WORST CASE" VAPOR EXPOSURE CALCULATION

1) P* = 1,316 * Concn * PVap / (Solub * Foc * Koc)
2) % Exp = P* / PEL

Concn = Soil Concentration of Contaminant
PVap = Vapor Pressure of Pure Chemical
P* = Vapor Pressure of Contaminant over Soil
Solub = Saturation Water Solubility NOTE: Impossibly high solubilities appear for ketones to allow calculation
Foc = Fraction of Soil that is Organic Carbon
Koc = Organic Carbon Partition Coefficient (for the chemical)

Sauget Support "WORST CASE" VAPOR EXPOSURE CALCULATION
Sampling for volatile compounds in water

PARAMETER: CONTAMINANT	MAXIMUM CONCENTR'N (site water) (ug/l)	Water Solubility mg/l	Vapor Pressure When Pure (torr)	Exposure Limit (OSHA) (ppm)	Saturation Concentr'n in Air (ppm)	Fraction of Total vapor in Air (% by ppm)	Saturation Concentr'n in Air % of PEL	NAME OF CHEMICAL			Corrected for PID Calibrated to Benzene		Corrected for PID Calibrated to Benzene Add high #s for @min	
Acetone	0 18	3000000	180	750	0 000	0 00%	0 00%	Acetone	0 00%	1 37E+08	8.64E+07	Acetone	8.64E+07	1.23E+08
	1E-09												1 00E+10	1.43E+10
Benzene	4 3	600	75	1	0 707	27.21%	70.71%	Benzene	0.27	3.67	3 67E+00	Benzene	3.67	5.25
Bromochloromethane	0 001	10000	300	200	0 000	0 00%	0 00%	Bromochloromethane	0 00%	1 32E+07	0.00E+00	Bromochloromethane	1 00E+10	1 43E+10
Carbon Disulfide	1E-09	2000	300	4	0 000	0 00%	0.00%	Carbon Disulfide	0.00%	5.27E+10	7.42E+08	Carbon Disulfide	7.42E+08	1 06E+09
Carbon Tetrachloride	0.031	800	91	2	0 005	0 18%	0 23%	Tetrachloromethane	0 09%	1 12E+03			1.00E+10	1.43E+10
Chlorobenzene	3.1	500	11 8	10	0 096	3 70%	0.96%	Chlorobenzene	0.37%	2 70E+02	2 70E+02	Chlorobenzene	2 70E+02	3 86E+02
Chloroform	3	7950	246	2	0 122	4 70%	6 11%	Trichloromethane	2 35%	4 26E+01			1 00E+10	1 43E+10
Dibromochloromethane	1E-09	4700	50	1	0 000	0 00%	0 00%	Chlorodibrometha	0 00%	1 86E+11	0 00E+00	Dibromochloromethane	1 00E+10	1 43E+10
Dichlorobenzenes	1E 09	156	1 47	75	0 000	0 00%	0 00%	Dichlorobenzene	0 00%	1 57E+13	2 04E+13	Dichlorobenzenes	2 04E+13	2 92E+13
1,1-Dichloroethane	0 003	5060	227	100	0 000	0 01%	0 00%	1,1-Dichloroethane	0 00%	1 47E+06	0 00E+00	1,1-Dichloroethane	1 00E+10	1 43E+10
1,2-Dichloroethane	0 48	8524	90	1	0 007	0 26%	0 67%	1,2-Dichloroethane	0 26%	3 90E+02	0 00E+00	1,2-Dichloroethane	1 00E+10	1 43E+10
1,1-Dichloroethene	0.01	2500	591	1	0 003	0 12%	0 31%	Vinylidene chloride	0 12%	8 36E+02	5 85E+02	1,1-Dichloroethene	5 85E+02	8 36E+02
1,2-Dichloroethene	0 64	800	200	200	0 210	8 10%	0 11%	1,2-Dichloroethene	0 04%	2 47E+03	1 73E+03	1,2-Dichloroethene	1 73E+03	2 47E+03
1,4-Dioxane	1E-09	2000000	30	25	0 000	0 00%	0 00%	1,4-Dioxane	0 00%	3 29E+15	3 29E+15	1,4-Dioxane	3 29E+15	4 70E+15
Ethylbenzene	0 84	150	7 1	100	0 052	2 01%	0 05%	Ethyl Benzene	0 02%	4 97E+03	5 76E+03	Ethylbenzene	5 76E+03	8 23E+03
Ethyl Chloride	1E-09	5740	1000	1000	0 000	0 00%	0 00%	Ethyl Chloride	0 00%	1 13E+13	0 00E+00	Ethyl Chloride	1 00E+10	1 43E+10
	1E-09												1 00E+10	1 43E+10
Methyl Butyl Ketone	1E-09	5000000	3 8	5	0 000	0 00%	0 00%	Methyl Butyl Ketone	0 00%	1 30E+16	6 76E+15	Methyl Butyl Ketone	6 76E+15	9 65E+15
Methyl Chloride	1E-09	4800	3756	50	0 000	0 00%	0 00%	Chloromethane	0 00%	1 26E+11	0 00E+00	Methyl Chloride	1 00E+10	1 43E+10
Methyl Ethyl Ketone	1E-09	3560000	100	200	0 000	0 00%	0 00%	Methyl Ethyl Ketone	0 00%	1 41E+16	8 02E+15	Methyl Ethyl Ketone	8 02E+15	1 15E+16
Methylene Chloride	0 44	13000	435	50	0 019	0 75%	0 04%	Dichloromethane	0 01%	6 71E+03	0 00E+00	Methylene Chloride	1 00E+10	1 43E+10
Naphthalene	1E-09	31 7	0 082	10	0 000	0 00%	0 00%	Naphthalene	0 00%	7 64E+12	1 50E+13	Naphthalene	1 50E+13	2 15E+13
Propylene Dichloride	1E-09	2600	40	75	0 000	0 00%	0 00%	Propene Dichloride	0 00%	9 63E+12			1 00E+10	1 43E+10
Styrene	0 05	300	7	50	0 002	0 06%	0 00%	Styrene	0 00%	8 47E+04	8 21E+04	Styrene	8 21E+04	1 17E+05
Tetrachloroethane	1E-09	2900	7	1	0 000	0 00%	0 00%	Tetrachloroethane	0 00%	8 18E+11	0.00E+00	Tetrachloroethane	1 00E+10	1 43E+10
Tetrachloroethylene	0 47	150 3	18 49	25	0 076	2 93%	0 30%	Tetrachloroethene	0 12%	8 54E+02	6 41E+02	Tetrachloroethylene	6 41E+02	9 15E+02
Toluene	7 3	500	25	50	0 480	18.48%	0 96%	Toluene	0 37%	2 71E+02	2 71E+02	Toluene	2 71E+02	3 87E+02
1,1,1-Trichloroethane	0 051	4400	124	350	0 002	0 07%	0 00%	Methyl Chloroform	0 00%	4 81E+05			1 00E+10	1 43E+10
1,1,2-Trichloroethane	1E-09	4500	25	10	0 000	0 00%	0 00%	1,1,2-Trichloroethane	0 00%	3 56E+12			1 00E+10	1 43E+10
Trichloroethylene	0 8	1100	75	50	0 072	2 76%	0 14%	Trichloroethene	0 06%	1 81E+03	1 61E+03	Trichloroethylene	1 61E+03	2 30E+03
Vinyl Chloride	0 79	1100	760	1	0 718	27.63%	71.80%	Vinyl Chloride	0.28	3.62	1.81E+00	Vinyl Chloride	1.81	2.58
Xylene	0 4	130	6 6	100	0 027	1 03%	0 03%	Xylene	0 01%	9 73E+03	1 09E+04	Xylene	1 09E+04	1 56E+04
										3.62			1.81	2.58
			Combined Volatiles Level (ppm)		2 60	100 00%							Action level for total va	Action level for total vapor
					Fraction Combined Exposure Limit		1 524						based on cmpd closes to its PEL, including PID response, calibrat to Benzene	based on cmpd closest to its PEL, including PID response, calibrated to Isobutylene

"WORST CASE" VAPOR EXPOSURE CALCULATION

1) P* = 1,000,000 * Concn * PVap / (Solub * 760)
2) % Exp = P* / PEL

Concn = Water Concentration of Contaminant
PVap = Vapor Pressure of Pure Chemical
Solub = Saturation Water Solubility NOTE: Impossibly high solubilities appear for ketones to allow calculation

Sauget Support / EXPOSURE CALCULATION WORKSHEET
Sampling

Safety factor for this site = 5

Chemical	Exposure Limit (mg/m3)	Maximum Soil Concentration (mg/kg)	Exposure Limit Based on Single Compound (mg/m3)	Dust Quotient for Each Compound (level/limit)	Problem from Single Compound [5mg/m3)/ELmix]
Aluminum	5	49200	2 03E+01	9 84E+03	2 46E-01
Antimony	0 5	6660	1 50E+01	1 33E+04	3 33E-01
Arsenic	0 01	6000	**0.33**	6 00E+05	**15.00**
Barium	0.5	45900	**2.18**	9.18E+04	**2.30**
Beryllium	0 002	1530	**0.26**	7 65E+05	**19.13**
Cadmium	0 005	294	**3.40**	5 88E+04	**1.47**
Calcium Oxide	5	985	1 02E+03	1 97E+02	4 93E-03
Cs-137(pCi/l)	60	1E-09	1 20E+16	1 67E-11	4 17E-16
Chlordane	1	1E-09	2 00E+14	1 00E-09	2 50E-14
Chromium	0 5	1E-09	1 00E+14	2 00E-09	5 00E-14
Chrome (hex)	0 01	1E-09	2 00E+12	1 00E-07	2 50E-12
Cobalt	0 02	180	2 22E+01	9 00E+03	2 25E-01
Copper	1	91800	**2.18**	9 18E+04	**2.30**
Cyanides	5	3180	3 14E+02	6 36E+02	1 59E-02
Dirt	15	1E-09	3 00E+15	6 67E-11	1 67E-15
Endosulfan	0 1	0 21	9 52E+04	2 10E+00	5 25E-05
Fluorides	2 5	1E-09	5 00E+14	4 00E-10	1 00E-14
Iron Oxide Fume	10	36500	5 48E+01	3 65E+03	9 13E-02
Lead	0 05	32400	**0.31**	6 48E+05	**16.20**
Magnesium Oxide	15	1E-09	3 00E+15	6 67E-11	1 67E-15
Manganese	1	36500	**5.48**	3.65E+04	9 13E-01
Mercury	0.05	467	2 14E+01	9 34E+03	2 34E-01
Nickel	1	15100	1 32E+01	1 51E+04	3 78E-01
Oil Mist	5	1E-09	1 00E+15	2 00E-10	5 00E-15
PCBs	0 5	57093	**1.75**	1 14E+05	**2.85**
PNAs	0.2	1E-09	4 00E+13	5 00E-09	1 25E-13
Phthalates	5	260	3 85E+03	5 20E+01	1 30E-03
Potassium Oxide	15	1E-09	3 00E+15	6 67E-11	1 67E-15
Pu-239(pCi/l)	0 003	1E-09	6 00E+11	3 33E-07	8 33E-12
Ra-226(pCi/l)	0.3	1E-09	6 00E+13	3 33E-09	8 33E-14
RDX	1 5	1E-09	3 00E+14	6 67E-10	1 67E-14
Selenium	0 2	8890	**4.50**	4 45E+04	**1.11**
Silicon Dioxide	0 05	150	6 67E+01	3 00E+03	7 50E-02
Silver	0 01	348	**5.75**	3 48E+04	8 70E-01
Sodium Oxide	2	1E-09	4 00E+14	5 00E-10	1 25E-14
Sr-90(pCi/l)	8	430	3 72E+03	5 38E+01	1 34E-03
Sulfur Trioxide	1	1E-09	2 00E+14	1 00E-09	2 50E-14
Thallium	0.1	21	9 52E+02	2 10E+02	5 25E-03
Th-230(pCi/l)	0.003	1E-09	6 00E+11	3 33E-07	8 33E-12
Tin	2	260	1 54E+03	1 30E+02	3 25E-03
Titanium	10	110	1 82E+04	1 10E+01	2 75E-04
Trinitrobenzene	0 07	1E-09	1 40E+13	1 43E-08	3 57E-13
Trinitrotoluene	0 5	1E-09	1 00E+14	2 00E-09	5 00E-14
Vanadium	0.05	194000	**0.05**	3 88E+06	**97.00**
Zinc	5	71000	1 41E+01	1 42E+04	3 55E-01
			Sum	6 44E+06	

Dust Exposure Level at PEL for Mixture = **0.03**

EQUATIONS USED IN THIS CALCULATION

Dust action level = (1E+6)(Exposure Limit mg/m3)
(For one dust) / (Concentration mg/kg)(Safety Factor)

Dust action level = (1E+6) / (Safety Factor)
(For mixed dusts) / Sum of [(Concentration mg/kg) / (Exposure Limit)]

Site Characterization Program

PID Action Levels for Compound of Greatest Concern	PID Calibrated to Benzene PPM	PID Calibrated to Isobutylene PPM
Water Vapor	*1.8*	*2.6*
Soil Vapor	*3.8*	*5.4*

min-RAM Action Level for Compound of Greatest Concern	(mg/m3)
Dust Level	*0.03*

IONIZATION POTENTIAL TABLES

	eV		eV
Acetaldehyde	10.21	2-bromobutane	9.948
Acetamide	9.77	1-bromobutanone	9.54
Acetic Acid	10.35	1-bromo-2-chloroethane	10.63
Acetone	9.69	Bromochloromethane	10.77
Acetonitrile	12.22	Bromodichloromethane	10.88
Acetylene	11.41	Bromoethane	10.24
Acetylene dichloride	9.80	Bromothene	9.8
Acrolein	10.10	Bromoform	10.51
Acrylic acid	10.09	1-bromo-3-hexanone	9.26
Acrylonitrile	10.9	Bromomethane	10.53
Allene	9.83	Bromomethyl ethyl ether	10.08
Allyl alcohol	9.67	1-bromo-2-methylpropane	10.09
Allyl chloride	10.20	2-bromo-2-methylpropane	9.98
Aminoethanol	9.87	1-bromopentane	10.10
Ammonia	10.15	1-bromopropane	10.18
Aniline	7.7	1-bromopropene	9.30
Anisole	8.2	3-bromopropene	9.7
Arsine	10.6	2-bromothiophene	8.63
Benzaldehyde	9.53	o-bromotoluene	8.78
Benzene	9.245	m-bromotoluene	8.81
Benzenethiol	8.33	p-bromotoluene	8.67
Benzonitrile	9.7	1, 2-butadiene	9.57
Benzotrifluoride	9.68	2, 3-butadione	9.23
Benzyl chloride	10.16	n-butanal	9.83
Biphenyl	8.27	2-butanal	9.73
Bromobenzene	8.98	n-butane	10.63
1-bromobutane	10.13	1-butanethiol	9.14

	eV		eV
2-butanone	9.53	Caprolactam	9.86
iso-butanol	10.47	Carbon disulfide	10.07
sec-butanol	10.23	Carbon tetrachloride	11.47
tert-butanol	10.25	Carbon dioxide	13.79
2-butanol	10.1	Carbon monoxide	14.01
1-butene	9.58	o-chloroiodobenzene	8.35
cis-2-butene	9.13	1-chloro-2-methylbenzene	8.72
trans-2-butene	9.13	1-chloro-2-methylbenzene	8.61
3-butene nitrile	10.39	1-chloro-4-methylbenzene	8.78
sec-butyl acetate	9.91	Chloromethylethyl ether	10.08
n-butyl alcohol	10.04	Chloromethylmethyl ether	10.25
n-butyl amine	8.71	1-chloro-2-methylpropane	10.66
i-butyl amine	8.70	2-chloro-2-methylpropane	10.61
s-butyl amine	8.70	1-chloropropane	10.82
t-butyl amine	8.64	2-chloropropane	10.78
n-butyl benzene	8.69	3-chloropropene	10.04
i-butyl benzene	8.68	2-chlorothiphene	8.68
t-butyl benzene	8.68	o-chlorotoluene	8.83
Butyl cellosolve	8.68	m-chlorotoluene	8.83
n-butyl mercaptan	9.15	p-chlorotoluene	8.69
i-butyl ethanoate	9.95	Chlorotrifluoroethane	10.4
iso-butyl mercaptan	9.12	Chlorotrifluoromethane	9.73
i-butyl methanoate	10.46	Chlorobenzene	9.07
i-butyne	10.18	Chlorobromomethane	10.77
2-butyne	9.85	1-chlorobutane	10.67
n-butyl acetate	10.01	2-chlorobutane	10.65
n-butyraldehyde	9.86	1-chlorobutanone	9.54

	eV		eV
1-chloro-2, 3 epoxy propane	10.60	1, 1-dibromoethane	10.19
Chloroethane (ethyl chloride)	10.97	1, 3-dibromopropane	10.07
Chloroethene	10.0	o-dichlorobenzene	9.07
2-chloroethoxyethene	10.61	m-dichlorobenzene	9.12
1-chloro-2-fluorobenzene	9.15	p-dichlorobenzene	8.94
1-chloro-3-fluorobenzene	9.21	1, 1-dichloroethane	11.06
1-chloro-2-fluoroethene (cis)	9.87	1, 2-dichloroethane	11.12
1-chloro-2-fluoroethene (trans)	9.87	cis-dichloroethene	9.65
Chloroform	11.42	trans-dichloroethene	9.65
cresols (cresylic acid)	8.83	Dichlorofluoromethane	11.75
Crotonaldehyde	11.84	Dichloromethane	11.35
Crotonaldehyde	9.73	1, 2-dichloropropane	10.87
Cyanoethane	10.91	1, 3-dichloropropane	10.85
Cyanogen bromide	11.95	1, 1-dichloropropanone	9.71
Cyanogen chloride	12.49	2, 3-dichloropropene	9.82
3-cyanopropene	10.39	Diisobutyl Ketone	9.04
Cyclobutane	10.5	Diisopropylamine	7.73
Cyclohexane	9.88	Dimethyl amine	8.24
Cyclohexanone	9.14	2, 3-dimethylbutadiene	8.72
Cyclohexene	8.95	2, 2-dimethylbutane	10.05
Cyclo-octateraene	7.99	2, 2-dimethyl butane-3-one	9.18
Cyclopentadiene	8.58	2, 3-dimethylbutane	10.01
Cyclopentane	10.52	3, 3-dimethyl butanone	9.17
Cyclopentene	9.01	2, 3-dimethyl-2 butene	8.30
Cyclopropane	10.06	3, 5-dimethyl-4-heptanone	9.04
Cyclopropene	9.95	2, 2-dimethyl-3-pentanone	8.98
Dibromoethane	10.49	2, 2-dimethyl propane	10.35

	eV		eV
Dimethyl disulfide	8.46	Ethane	11.65
Dimethyl ether	10.00	Ethanal	11.65
N, N Dimethyl formamide	9.12	Ethanol	10.21
Dimethyl sulfide	8.685	Ethanethiol	9.285
p-Dioxane	9.13	Ethanethiol (Ethyl mercaptan)	9.29
Di-n-propyl disulfide	8.27	Ethene (Ethylene)	10.515
Di-n- propyl ether	9.27	Ethyl acetate	10.11
Di-i- propyl ether	9.20	Ethyl alcohol	10.48
Di-n-propyl amine	7.84	Ethyl amine	8.86
Di-n-propyl sulfide	8.30	Ethyl amyl ketone	9.10
Dicyclopentadiene	7.74	Ethyl benzene	8.76
Dibutyl amine	7.69	Ethyl bromide	10.29
Diethoxymethane	9.70	Ethyl butyl ketone	9.02
Diethyl	8.01	Ethyl chloride (Chloroethane)	10.97
Diethyl ether	9.53	Ethyl chloroacetate	10.20
N, N-diethyl formamide	8.89	Ethyl ethanoate	10.10
Diethyl Ketone	9.32	Ethyl disulfide	8.27
Diethyl Sulfide	8.43	Ethyl disulfane	9.4
o-difluorobenzene	9.31	Ethyl formate	10.61
p-difluorobenzene	9.15	Ethyl iodine	9.33
Difluorodibromomethane	11.10	Ethyl mercaptan	9.29
Difluoromethylbenzene	9.45	Ethyl methanoate	10.61
1, 1-dimethoxyethane	9.65	Ethyl isothiocyanate	9.14
Dimethoxyethane	9.65	Ethyl methyl sulfide	8.55
Dimethoxymethane	10.0	Ethyl nitrate	11.22
Diiodomethane	9.34	Ethyl propanoate	10.0
Epichlorohydrin	10.60	Ethyl trichloroacetate	10.44

	eV		eV
Ethylene dibromide (EDB)	10.37	n-Heptane	10.07
Ethylene chlorohydrin	10.90	4-Heptanone	9.12
Ethylene oxide	10.565	2-Heptanone	9.33
Ethylbenzene	8.87	n-Hexane	10.18
Ethyne	11.41	Hexafluoroacetone	11.81
Fluorobenzene	9.195	Hexafluorobenzene	9.39
Fluoroethane	12.00	Hexafluoropropene	10.3
Fluoroethene	10.37	2-Hexanone	9.34
Mono-fluoromethanal	11.4	Hexamethylbenzene	7.85
Fluorotribromomethane	11.77	1-Hexene	9.46
o-fluorotoluene	8.91	Hydrazine	9.00
m-fluorotoluene	8.91	Hydrofluoric acid	9.88
Formaldehyde	10.87	Hydrogen	15.43
Formic acid	10.37	Hydrogen Cyanide	13.73
Formamide	10.25	Hydrogen selenide	9.88
Freon 11 ($CFCl_3$)	11.77	Hydrogen sulfide	10.46
Freon 12 (CF_2Cl_2)	12.31	Hydrogen telluride	9.138
Freon 13 (CF_3Cl)	12.91	Iodine	9.28
Freon 13 B-I	12.08	Iodobenzene	8.73
Freon 14 (neat)	16.25	1-iodobutane	9.71
Freon 22 ($CHClF_2$)	12.45	2-iodobutane	9.09
Freon 113 (CF_3CCl_3)	11.78	Iodoethane (Ethyl iodide)	9.33
Freon 114	12	Iodomethane (Methyl iodide)	9.54
2-furaldehyde	9.21	1-iodo-2-methylpropane	9.18
Furan	8.89	1-iodo-2-methylpropane	9.02
Furfural	9.21	1-iodopentane	9.19
Genetron 101	11.98	1-iodopropane	9.26

	eV		eV
2-iodopropane	9.17	2-methylpropanal	9.7
o-iodotoluene	8.62	2-methyl-2-propanol	8.7
m-iodotoluene	8.61	Methyl acetate	10.27
p-iodotoluene	8.50	2-methylpropene	9.23
Isoamyl acetate	9.90	Methyl acrylate	10.7?
Isoamyl alcohol	10.16	Methyl n-propyl ketone	9.39
Isobutane	10.57	Methyl alcohol	10.85
Isobutyl amine	8.70	Methyl styrene	8.35
Isobutyl acetate	9.97	Methyl amine	8.97
Isobutyl alcohol	10.47	Methyl bromide	10.53
Isobutyl formate	10.46	Methyl butyrate	10 0
Isobutylene	9.44	Methyl Chloroacetate	10.35
Isobutyraldehyde	9.74	Methyl chloride	11.28
Isopentane	10.32	Methyl chloroform	11.??
Isopropanol	10.17	Methylcyclohexane	9.85
Isopropyl acetate	9.99	4-methylcyclohexene	8.91
Isopropyl alcohol	10.16	2-methyl-1, 3-butadiene	8.85
Isopropyl amine	8.72	2-methybutanal	9.7
Isopropyl benzene	8.75	2-methylbutane	10.31
Isopropyl ether	9.20	2-methyl-1-butene	9.12
Isovaleraldehyde	9.71	3-methyl-1-butene	9.51
Methane	12.48	3-methyl-2-butene	8.67
Mesitylene	8.40	Methyl n-butyl ketone	9.34
Mesityl oxide	9.08	Methylcyclopropane	9.83
Methanol	10.85	Methyl dichloroacetate	10.44
Methanethiol	9.44	Methyl disulfide	8.46
2-methylpropane	10.56	Methyl ethanoate	10.27

	eV		eV
Methyl ethyl ether	9.81	Oxygen	12.075
Methyl ethyl ketone	9.53	n-pentane	10.34
Methyl ethyl sulfide	8.55	i-pentane	10.32
2-methyl furan	8.39	Pentachloroethane	11.28
Methyl iodide	9.54	1, 3-pentadiene (cis)	8.65
Methyl isobutyl ketone	9.30	1, 3-pentadiene (trans)	8.56
Methyl isobutyrate	9.98	Pentafluorobenzene	9.84
Methyl isopropyl ketone	9.32	Pentamethylbenzene	7.92
Methyl methacrylate	9.74	n-pentanal	9.82
Methyl methanoate	10.82	2, 4-pentanedione	8.87
Methyl mercaptan	9.44	2-pentanone	9.39
2-methylpentane	10.11	3-pentanone	9.32
3-methylpentane	10.073	1-pentene	9.50
Morpholine	8.88	Perchloroethylene	9.32
Napthalene (I)	8.12	Perfluoro-2-butene	11.25
Nitric oxide (I)	9.25	Perfluoro-1-heptene	10.48
Nitrobenzene	9.82	n-perfluoropropyl iodide	10.26
Nitroethane	9.92	(n-perfluoropropyl)-iodomethane	9.96
Nitrogen	15.6		
Nitrotoluene	10.88	(n-perfluoropropyl)-methyl ketone	10.58
Nitromethane	11.08	Phenol	8.50
n-Nonane	10.21	Phenyl ether	8.09
5-nonanone	9.10	Phenyl isocyanete	8.77
n-Octane	10.24	Phosgene	11.77
3-octanone	9.19	Phosphine	10.1
4-octanone	9.10	Pinene	8.07
1-octene	9.52	Propadiene	10.19

	eV		eV
n-propanal	9.95	1, 2, 3, 4-tetrafluorobenzene	9.61
n-propanol	10.51	1, 2, 3, 5-tetrafluorobenzene	9.55
Propane	11.07	1, 2, 4, 5-tetrafluorobenzene	9.39
1-propanethiol	9.195	1, 2, 4, 5-tetramethylbenzene	8.03
Propanone	7.69	Tetrafluoroethene	10.12
Propenal (Acrolein)	10.10	Tetrahydropyran	9.26
Propene	9.73	Tetrachloroethylene	9.32
Prop-1-ene-2-ol	8.20	Tetrachloromethane	11.4
Prop-2-ene-1-ol	9.67	Tetrahydrofuran	9.45
Propionaldehyde	9.98	Thioethanol	9.29
Propionic acid	10.34	Thiomethanol	9.44
Propionitrile	11.84	Thiophene	8.86
n-Propyl acetate	10.04	1-thiopropanol	9.20
n-Propyl alcohol	10.20	Toluene (l)	8.82
i-Propyl alcohol	10.16	Tribromoethene	9.27
n-Propyl amine	8.78	Tribromomethane	10.51
n-Propyl benzene	8.72	1, 1, 1-trichlorobutanone	9.54
Propylene	9.73	1, 1, 1-trichloroethane	11.25
Propylene oxide	10.22	Trichloroethene	9.45
n-Propyl ether	9.27	Trichloroethylene	9.45
n-Propyl formate	10.54	Trichloromethyl ethyl ether	10.08
Propyne	10.36	Trichloromethane	11.42
Pyridine	9.32	Triethylamine	7.50
Pyrrole	8.20	1, 2, 4-trifluorobenzene	9.37
Styrene	8.47	1, 3, 5-trifluorobenzene	9.30
2, 2, 4, 4-tetramethyl-3-pentanone	8.65	Trifluoroethene	10.14
1, 1, 2, 2-Tetrachloroethane	11.10	1, 1, 1-trifluoro-2-iodoethane	10.00

	eV
Trifluoroiodomethane	10.40
Trifluoromethylbenzene	9.68
Trifluoromethylcyclohexane	10.46
1, 1, 1-trifluoropropene	10.9
Trimethylamine	7.82
1, 2, 3-trimethylbenzene	8.48
1, 2, 4-trimethylbenzene	8.27
1, 3, 5-trimethylbenzene	8.39
2, 2, 4-trimethyl pentane	9.85
2, 2, 4-trimethyl-3-pentanone	8.82
n-Valderaldehyde	9.82
Vinyl acetate	9.19
Vinyl benzene (styrene)	8.47
Vinyl bromide	9.80
Vinyl chloride	10.00
4-vinylcyclohexene	8.93
Vinyl ethanoate	9.19
Vinyl flouride	10.37
Vinyl methyl ether	8.93
Water (H_2O)	12.59
o-xylene	8.56
m-xylene	8.56
p-xylene	8.445

Appendix B

MSDSs for constituents with exposure potential

International Chemical Safety Cards

BENZENE

ICSC: 0015

BENZENE
Cyclohexatriene
Benzol
C_6H_6
Molecular mass: 78.1

CAS # 71-43-2
RTECS # CY1400000
ICSC # 0015
UN # 1114
EC # 601-020-00-8

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Highly flammable.	NO open flames, NO sparks, and NO smoking.	Powder, AFFF, foam, carbon dioxide.
EXPLOSION	Vapour/air mixtures are explosive. Risk of fire and explosion: see chemical dangers.	Closed system, ventilation, explosion-proof electrical equipment and lighting. Do NOT use compressed air for filling, discharging, or handling. Use non-sparking handtools.	In case of fire: keep drums, etc., cool by spraying with water.
EXPOSURE		AVOID ALL CONTACT!	
INHALATION	Dizziness. Drowsiness. Headache. Nausea. Shortness of breath. Convulsions. Unconsciousness.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Refer for medical attention.
SKIN	MAY BE ABSORBED! Dry skin (further see Inhalation).	Protective gloves. Protective clothing.	Remove contaminated clothes. Rinse skin with plenty of water or shower. Refer for medical attention.
EYES		face shield, or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Abdominal pain. Sore throat. Vomiting (further see Inhalation).	Do not eat, drink, or smoke during work.	Rinse mouth. Do NOT induce vomiting. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent and remove to safe place. Do NOT wash away into sewer (extra personal protection: complete protective clothing including self-contained breathing apparatus).	Fireproof. Separated from food and feedstuffs, oxidants and halogens.	Do not transport with food and feedstuffs. F symbol T symbol R: 45-11-48/23/24/25 S: 53-45 UN Hazard Class: 3 UN Packing Group: II

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0015

International Chemical Safety Cards

BENZENE

ICSC: 0015

PHYSICAL STATE; APPEARANCE:
COLOURLESS LIQUID, WITH CHARACTERISTIC ODOUR.

PHYSICAL DANGERS:
The vapour is heavier than air and may travel along the ground; distant ignition possible.

CHEMICAL DANGERS:
Reacts violently with oxidants and halogens causing fire and explosion hazard.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: 10 ppm; 32 mg/m^3 (as TWA) A2 (ACGIH 1991-1992).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation and through the skin.

INHALATION RISK:
A harmful contamination of the air can be reached rather quickly on evaporation of this substance at 20°C; on spraying or dispersion, however, much faster.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the skin and the respiratory tract. Swallowing the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis. The substance may cause effects on the central nervous system. Exposure far above the occupational exposure limit may result in unconsciousness.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
The liquid defats the skin. The substance may have effects on the blood forming organs, liver and immune system. This substance is carcinogenic to humans.

Boiling point: 80°C
Melting point: 6°C
Relative density (water = 1): 0.9
Solubility in water, g/100 ml at 25°C: 0.18
Vapour pressure, kPa at 20°C: 10
Relative vapour density (air = 1): 2.7

Relative density of the vapour/air-mixture at 20°C (air = 1): 1.2
Flash point: -11°C (c.c.)°C
Auto-ignition temperature: about 500°C
Explosive limits, vol% in air: 1.2-8.0
Octanol/water partition coefficient as log Pow: 2.13

NOTES

Use of alcoholic beverages enhances the harmful effect. Depending on the degree of exposure, periodic medical examination is indicated. The odour warning when the exposure limit value is exceeded is insufficient.

Transport Emergency Card: TEC (R)-7
NFPA Code: H2; F3; R0;

ADDITIONAL INFORMATION

ICSC: 0015 **BENZENE**

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International Chemical Safety Cards

VANADIUM PENTOXIDE

ICSC: 0596

VANADIUM PENTOXIDE
Divanadium pentoxide
Vanadic anhydride
Vanadium(V)oxide
V_2O_5
Molecular mass: 181.9

CAS # 1314-62-1
RTECS # YW2450000 (dust), YW2460000 (fume)
ICSC # 0596
UN # 2862
EC # 023-001-00-8

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Not combustible.		In case of fire in the surroundings: all extinguishing agents allowed.
EXPLOSION			
EXPOSURE		PREVENT DISPERSION OF DUST! STRICT HYGIENE!	
INHALATION	Sore throat. Cough. Burning sensation. Shortness of breath. Laboured breathing. Wheezing.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Half-upright position. Refer for medical attention.
SKIN	Redness. Burning sensation. Pain.	Protective gloves.	Remove contaminated clothes. Rinse skin with plenty of water or shower.
EYES	Pain. Redness. Conjunctivitis.	Safety goggles, or eye protection in combination with breathing protection if powder.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Abdominal cramps. Diarrhoea. Drowsiness. Nausea. Unconsciousness. Vomiting.	Do not eat, drink, or smoke during work.	Induce vomiting (ONLY IN CONSCIOUS PERSONS!). Give plenty of water to drink. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Sweep spilled substance into containers; if appropriate, moisten first to prevent dusting. Carefully collect remainder, then remove to safe place. Do NOT let this chemical enter the environment (extra personal protection: P2 filter respirator for harmful particles).	Separated from food and feedstuffs.	Do not transport with food and feedstuffs. Xn symbol R: 20 S: (2-)22 UN Hazard Class: 6.1 UN Packing Group: II

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0596

International Chemical Safety Cards

VANADIUM PENTOXIDE

ICSC: 0596

PHYSICAL STATE; APPEARANCE:
YELLOW TO RED CRYSTALLINE POWDER OR SOLID IN VARIOUS FORMS.

PHYSICAL DANGERS:

CHEMICAL DANGERS:
Upon heating, toxic fumes are formed. Reacts with combustible substances.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV (respirable dust or fume, as V2O5): 0.05 mg/m^3 A4 (TWA) (ACGIH 1996).
MAK: 0.05 mg/m^3; (1996).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation of its aerosol and by ingestion.

INHALATION RISK:
Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly when dispersed.

EFFECTS OF SHORT-TERM EXPOSURE:
The aerosol of this substance irritates the eyes, the skin and the respiratory tract. Inhalation of high concentrations may cause lung oedema, bronchitis, bronchospasm. The effects may be delayed.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
Lungs may be affected by inhalation of high concentrations of dust or fumes. The substance may cause greenish-black discolouration of the tongue.

Boiling point (decomposes): 1750°C
Melting point: 690°C
Relative density (water = 1): 3.4
Solubility in water, g/100 ml: 0.8

The substance is harmful to aquatic organisms.

NOTES

Depending on the degree of exposure, periodic medical examination is indicated. The symptoms of lung oedema often do not become manifest until a few hours have passed and they are aggravated by physical effort. Rest and medical observation are therefore essential. Immediate administration of an appropriate spray, by a doctor or a person authorized by him/her, should be considered.

ADDITIONAL INFORMATION	

ICSC: 0596 **VANADIUM PENTOXIDE**

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International Chemical Safety Cards

TOLUENE

ICSC: 0078

TOLUENE
Methylbenzene
Toluol
$C_6H_5CH_3/C_7H_8$
Molecular mass: 92.1

CAS # 108-88-3
RTECS # XS5250000
ICSC # 0078
UN # 1294
EC # 601-021-00-3

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Highly flammable.	NO open flames, NO sparks, and NO smoking.	Powder, AFFF, foam, carbon dioxide.
EXPLOSION	Vapour/air mixtures are explosive.	Closed system, ventilation, explosion-proof electrical equipment and lighting. Prevent build-up of electrostatic charges (e.g., by grounding). Do NOT use compressed air for filling, discharging, or handling.	In case of fire: keep drums, etc., cool by spraying with water.
EXPOSURE		STRICT HYGIENE! AVOID EXPOSURE OF (PREGNANT) WOMEN!	
INHALATION	Dizziness. Drowsiness. Headache. Nausea. Unconsciousness.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Artificial respiration if indicated. Refer for medical attention.
SKIN	Dry skin. Redness.	Protective gloves.	Remove contaminated clothes. Rinse and then wash skin with water and soap. Refer for medical attention.
EYES	Redness. Pain.	Safety goggles or face shield.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Abdominal pain. Burning sensation (further see Inhalation).	Do not eat, drink, or smoke during work.	Rinse mouth. Give a slurry of activated charcoal in water to drink. Do NOT induce vomiting. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Collect leaking liquid in sealable containers. Absorb remaining liquid in sand or inert absorbent and remove to safe place. Do NOT wash away into sewer (extra personal protection: self-contained breathing apparatus).	Fireproof. Separated from strong oxidants.	F symbol Xn symbol R: 11-20 S: (2-)16-25-29-33 UN Hazard Class: 3 UN Packing Group: II

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0078

International Chemical Safety Cards

TOLUENE

ICSC: 0078

PHYSICAL STATE; APPEARANCE:
COLOURLESS LIQUID , WITH CHARACTERISTIC ODOUR.

PHYSICAL DANGERS:
The vapour is heavier than air and may travel along the ground; distant ignition possible. As a result of flow, agitation, etc., electrostatic charges can be generated.

CHEMICAL DANGERS:
Reacts violently with strong oxidants causing fire and explosion hazard.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: 50 ppm; 188 mg/m^3 (as TWA) (skin) (ACGIH 1993-1994).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation, through the skin and by ingestion.

INHALATION RISK:
A harmful contamination of the air can be reached rather quickly on evaporation of this substance at 20°C.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the eyes and the respiratory tract. Exposure could cause central nervous system depression. Exposure at high levels may result in cardiac dysrhythmia, unconsciousness and death.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the central nervous system, resulting in decreased learning ability and psychological disorders. Animal tests show that this substance possibly causes toxic effects upon human reproduction.

Boiling point: 111°C
Melting point: -95°C
Relative density (water = 1): 0.87
Solubility in water: none
Vapour pressure, kPa at 20°C: 2.9
Relative vapour density (air = 1): 3.2

Relative density of the vapour/air-mixture at 20°C (air = 1): 1.06
Flash point: 4°C c.c.°C
Auto-ignition temperature: 480°C
Explosive limits, vol% in air: 1.1-7.1
Octanol/water partition coefficient as log Pow: 2.69

NOTES

Depending on the degree of exposure, periodic medical examination is indicated.

Transport Emergency Card: TEC (R)-31
NFPA Code: H 2; F 3; R 0;

ADDITIONAL INFORMATION

ICSC: 0078 **TOLUENE**

IMPORTANT LEGAL NOTICE:	Neither the CEC or the IPCS nor any person acting on behalf of the CEC or the IPCS is responsible for the use which might be made of this information. This card contains the collective views of the IPCS Peer Review Committee and may not reflect in all cases all the detailed requirements included in national legislation on the subject. The user should verify compliance of the cards with the relevant legislation in the country of use.

International Chemical Safety Cards

BERYLLIUM

ICSC: 0226

BERYLLIUM
Glucinium
(powder)
Be
Atomic mass: 9.0

CAS # 7440-41-7
RTECS # DS1750000
ICSC # 0226
UN # 1567
EC # 004-001-00-7

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Combustible.	NO open flames.	Special powder, dry sand, NO other agents.
EXPLOSION	Finely dispersed particles form explosive mixtures in air.	Prevent deposition of dust; closed system, dust explosion-proof electrical equipment and lighting.	
EXPOSURE		PREVENT DISPERSION OF DUST! AVOID ALL CONTACT!	IN ALL CASES CONSULT A DOCTOR!
INHALATION	Cough. Shortness of breath. Sore throat. Weakness. Symptoms may be delayed (see Notes).	Local exhaust. Breathing protection.	Fresh air, rest. Refer for medical attention.
SKIN	Redness.	Protective gloves. Protective clothing.	Remove contaminated clothes. Rinse skin with plenty of water or shower.
EYES	Redness. Pain.	Face shield or eye protection in combination with breathing protection if powder.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION		Do not eat, drink, or smoke during work. Wash hands before eating.	Rinse mouth. Do NOT induce vomiting. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Evacuate danger area! Consult an expert! Carefully collect the spilled substance into containers; if appropriate moisten first, then remove to safe place. Do NOT let this chemical enter the environment (extra personal protection: complete protective clothing including self-contained breathing apparatus).	Separated from strong acids, bases, chlorinated solvents, food and feedstuffs.	Unbreakable packaging; put breakable packaging into closed unbreakable container. Do not transport with food and feedstuffs. T+ symbol R: 49-25-26-36/37/38-43-48/23 S: 53-45 Note: E UN Hazard Class: 6.1 UN Subsidiary Risks: 4.1 UN Packing Group: II

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0226

International Chemical Safety Cards

BERYLLIUM

ICSC: 0226

PHYSICAL STATE; APPEARANCE:
GREY TO WHITE METAL OR POWDER.

PHYSICAL DANGERS:
Dust explosion possible if in powder or granular form, mixed with air.

CHEMICAL DANGERS:
Reacts with strong acids and strong bases forming combustible gas (HYDROGEN - see ICSC # 0001). Forms shock sensitive mixtures with some chlorinated solvents, such as carbon tetrachloride and trichloroethylene.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV (as TWA): ppm; 0.002 mg/m^3 A2 (Suspected Human Carcinogen) (ACGIH 1994-1995).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation of its aerosol and by ingestion.

INHALATION RISK:
Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly when dispersed.

EFFECTS OF SHORT-TERM EXPOSURE:
The aerosol of this substance irritates the respiratory tract. Inhalation of dust or fumes may cause chemical pneumonitis. Exposure may result in death. The effects may be delayed. Medical observation is indicated.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
Repeated or prolonged contact may cause skin sensitization. Lungs may be affected by repeated or prolonged exposure to dust particles, resulting in chronic beryllium disease (cough, weight loss, weakness). This substance is carcinogenic to humans.

Boiling point: above 2500°C
Melting point: 1287°C
Relative density (water = 1): 1.9
Solubility in water: none

The substance is very toxic to aquatic organisms.

NOTES

Depending on the degree of exposure, periodic medical examination is indicated.

Transport Emergency Card: TEC (R)-61G10

Transport Emergency Card: TEC (R)-61G10
NFPA Code: H3; F1; R0

ADDITIONAL INFORMATION	

ICSC: 0226 **BERYLLIUM**

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International Chemical Safety Cards

SELENIUM

ICSC: 0072

SELENIUM
(powder)
Se
Atomic mass: 79.0

CAS # 7782-49-2
RTECS # VS7700000
ICSC # 0072
UN # 2658 (powder)
EC # 034-001-00-2

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Combustible. Gives off irritating or toxic fumes (or gases) in a fire.	NO open flames. NO contact with oxidants.	Powder, AFFF, foam, carbon dioxide.
EXPLOSION	Risk of fire and explosion with oxidants.		Use extinguishing media appropriate to surrounding fire conditions. NO contact with water.
EXPOSURE		PREVENT DISPERSION OF DUST! STRICT HYGIENE!	
INHALATION	Irritation of nose. Cough. Dizziness. Headache. Laboured breathing. Nausea. Sore throat. Vomiting. Weakness. Symptoms may be delayed (see Notes).	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Refer for medical attention.
SKIN	Redness. Skin burns. Pain. Discolouration.	Protective gloves. Protective clothing.	Rinse skin with plenty of water or shower. Refer for medical attention. Remove and isolate contaminated clothes.
EYES	Redness. Pain. Blurred vision.	Safety spectacles or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Metallic taste. Diarrhoea. Chills. Fever (further see Inhalation).	Do not eat, drink, or smoke during work.	Rinse mouth. Induce vomiting (ONLY IN CONSCIOUS PERSONS!). Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Do NOT wash away into sewer. Sweep spilled substance into containers; if appropriate, moisten first to prevent dusting. Carefully collect remainder, then remove to safe place (extra personal protection: P3 filter respirator for toxic particles).	Fireproof. Separated from strong oxidants, strong acids, food and feedstuffs. Dry.	Airtight. Do not transport with food and feedstuffs. T symbol R: 23/25-33 S: (1/2-)20/21-28-45 UN Hazard Class: 6.1 UN Packing Group: III

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0072

International Chemical Safety Cards

SELENIUM

ICSC: 0072

PHYSICAL STATE; APPEARANCE:
ODOURLESS SOLID IN VARIOUS FORMS. DARK RED-BROWN TO BLUISH-BLACK AMORPHOUS SOLID OR RED TRANSPARENT CRYSTALS OR METALLIC GREY TO BLACK CRYSTALS.

PHYSICAL DANGERS:

CHEMICAL DANGERS:
Upon heating, toxic fumes are formed. Reacts violently with oxidants and strong acids. Reacts with water at 50°C forming flammable hydrogen (see ICSC # 0001) and selenious acids. Reacts with incandescence on gentle heating with phosphorous and metals such as nickel, zinc, sodium, potassium, platinum.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: ppm; 0.2 mg/m^3 as TWA (ACGIH 1991-1992).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation, through the skin and by ingestion.

INHALATION RISK:
Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly by dispersion.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the eyes and the respiratory tract. Inhalation of dust may cause lung oedema (see Notes). Inhalation of fume may cause symptoms of asphyxiation, chills and fever and bronchitis. The effects may be delayed.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the respiratory tract, gastrointestinal tract, and skin , resulting in nausea, vomiting, cough, yellowish skin discolouration, loss of nails, garlic breath and bad teeth.

Boiling point: 685°C
Melting point: 170-217°C
Relative density (water = 1): 4.8

Solubility in water: none
Vapour pressure, Pa at 20°C: 0.1

NOTES

Do NOT take working clothes home.

ADDITIONAL INFORMATION

ICSC: 0072	SELENIUM

IMPORTANT LEGAL NOTICE:	Neither the CEC or the IPCS nor any person acting on behalf of the CEC or the IPCS is responsible for the use which might be made of this information. This card contains the collective views of the IPCS Peer Review Committee and may not reflect in all cases all the detailed requirements included in national legislation on the subject. The user should verify compliance of the cards with the relevant legislation in the country of use.

International Chemical Safety Cards

LEAD

ICSC: 0052

LEAD
Lead metal
Plumbum
(powder)
Pb
Atomic mass: 207.2

CAS # 7439-92-1
RTECS # OF7525000
ICSC # 0052

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Not combustible. Finely divided lead powder is flammable. Gives off irritating or toxic fumes (or gases) in a fire.	NO open flames, NO sparks, and NO smoking (if in powder form).	In case of fire in the surroundings: all extinguishing agents allowed.
EXPLOSION	Finely dispersed particles form explosive mixtures in air.	Prevent deposition of dust; closed system, dust explosion-proof electrical equipment and lighting.	
EXPOSURE		PREVENT DISPERSION OF DUST! STRICT HYGIENE! AVOID EXPOSURE OF (PREGNANT) WOMEN! AVOID EXPOSURE OF ADOLESCENTS AND CHILDREN!	IN ALL CASES CONSULT A DOCTOR!
INHALATION	Abdominal cramps. Drowsiness. Headache. Nausea. Vomiting. Weakness. Wheezing. Pallor. Hemoglobinuria. Collapse.	Ventilation (not if powder). Avoid inhalation of fine dust and mist. Local exhaust or breathing protection.	Fresh air, rest. Refer for medical attention.
SKIN			
EYES			
INGESTION	Abdominal cramps (further see Inhalation).	Do not eat, drink, or smoke during work. Wash hands before eating.	Rinse mouth. Induce vomiting (ONLY IN CONSCIOUS PERSONS!). Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Sweep spilled substance into containers; if appropriate, moisten first to prevent dusting. Carefully collect remainder, then remove to safe place. Do NOT let this chemical enter the environment (extra personal protection: P2 filter respirator for harmful particles).	Separated from strong oxidants, strong bases, strong acids, food and feedstuffs.	

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0052

International Chemical Safety Cards

LEAD

ICSC: 0052

PHYSICAL STATE; APPEARANCE:
BLUISH-WHITE OR SILVERY-GREY SOLID IN VARIOUS FORMS. TURNS TARNISHED ON EXPOSURE TO AIR.

PHYSICAL DANGERS:
Dust explosion possible if in powder or granular form, mixed with air.

CHEMICAL DANGERS:
Upon heating, toxic fumes are formed. Reacts with hot concentrated nitric acid, boiling concentrated hydrochloric and sulfuric acids. Attacked by pure water and by weak organic acids in the presence of oxygen.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: ppm; 0.15 mg/m^3 (as TWA) (ACGIH 1993-1994).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation of its aerosol and by ingestion.

INHALATION RISK:
Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance may cause effects on the gastrointestinal tract, blood, central nervous system and kidneys, resulting in colics, shock, anemia, kidney damage and encephalopathy. Exposure may result in death. The effects may be delayed. Medical observation is indicated.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
The substance may have effects on the gastrointestinal tract, nervous system, blood, kidneys and immune system, resulting in severe lead colics, paralysis of muscle groups of the upper extremities (forearm, wrist and fingers), anemia, mood and personality changes, retarded mental development, and irreversible nephropathy. May cause retarded development of the new-born. Danger of cumulative effect.

Boiling point: 1740°C
Melting point: 327.5°C
Relative density (water = 1): 11.34
Solubility in water: none

This substance may be hazardous to the environment; special attention should be given to air and water. In the food chain important to humans, bioaccumulation takes place, specifically in plants and water organisms, especially shellfish.

NOTES

Explosive limits are unknown in literature. Use of alcoholic beverages enhances the harmful effect. Depending on the degree of exposure, periodic medical examination is indicated. Do NOT take working clothes home. Refer also to cards for specific lead compounds, e.g., lead chromate (ICSC # 0003), lead(II) oxide (ICSC # 0288).

Transport Emergency Card: TEC (R)-61G12b

Transport Emergency Card: TEC (R)-61G12b

ADDITIONAL INFORMATION

ICSC: 0052 **LEAD**

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International Chemical Safety Cards

BARIUM

ICSC: 1052

BARIUM
Ba
Atomic mass: 137.3

CAS # 7440-39-3
RTECS # CQ8370000
ICSC # 1052
UN # 1400

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Flammable.	NO open flames.	Special powder, dry sand, NO hydrous agents, NO water.
EXPLOSION	Finely dispersed particles form explosive mixtures in air.	Prevent deposition of dust; closed system, dust explosion-proof electrical equipment and lighting.	
EXPOSURE		PREVENT DISPERSION OF DUST! STRICT HYGIENE!	
INHALATION	Cough. Sore throat.	Local exhaust or breathing protection.	Fresh air, rest. Refer for medical attention.
SKIN	Redness.	Protective gloves.	Remove contaminated clothes. Rinse skin with plenty of water or shower. Refer for medical attention.
EYES	Redness. Pain.	Safety goggles.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION		Do not eat, drink, or smoke during work.	Rinse mouth. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Sweep spilled substance into containers. Carefully collect remainder, then remove to safe place (extra personal protection: complete protective clothing including self-contained breathing apparatus).	Separated from halogenated solvents, strong oxidants, acids. Dry. Keep under inert gas, petroleum or oxygen-free liquid.	UN Hazard Class: 4.3 UN Packing Group: II

SEE IMPORTANT INFORMATION ON BACK

ICSC: 1052

International Chemical Safety Cards

BARIUM

ICSC: 1052

PHYSICAL STATE; APPEARANCE:
YELLOWISH TO WHITE LUSTROUS SOLID IN VARIOUS FORMS.

PHYSICAL DANGERS:

CHEMICAL DANGERS:
The substance may spontaneously ignite on contact with air (if in powder form). The substance is a strong reducing agent and reacts violently with oxidants and acids. Reacts with water, forming combustible gas (hydrogen - see ICSC # 0001) and barium hydroxide. Reacts violently with halogenated solvents causing fire and explosion hazard.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: ppm; 0.5 mg/m^3 (as TWA) (ACGIH 1992-1993).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by ingestion.

INHALATION RISK:

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the eyes, the skin, and the respiratory tract.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:

Boiling point: 1640°C
Melting point: 725°C
Relative density (water = 1): 3.6

Solubility in water: reaction
Vapour pressure, kPa at 1049°C: 1.3

NOTES

Reacts violently with fire extinguishing agents such as water, bicarbonate, powder, foam, and carbon dioxide. Rinse contaminated clothes (fire hazard) with plenty of water.

Transport Emergency Card: TEC (R)-43G14

ADDITIONAL INFORMATION

International Chemical Safety Cards

COPPER

ICSC: 0240

COPPER
(powder)
Cu
Atomic mass: 63.5

CAS # 7440-50-8
RTECS # GL5325000
ICSC # 0240

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Combustible.	NO open flames.	Special powder, dry sand, NO other agents.
EXPLOSION			
EXPOSURE		PREVENT DISPERSION OF DUST!	
INHALATION	Cough. Headache. Shortness of breath. Sore throat.	Local exhaust or breathing protection.	Fresh air, rest. Refer for medical attention.
SKIN	Redness.	Protective gloves.	Remove contaminated clothes. Rinse and then wash skin with water and soap.
EYES	Redness. Pain.	Safety goggles.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Abdominal pain. Nausea. Vomiting.	Do not eat, drink, or smoke during work.	Rinse mouth. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Sweep spilled substance into containers. Carefully collect remainder. Then remove to safe place (extra personal protection: P2 filter respirator for harmful particles).	Separated from: see Chemical Dangers.	

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0240

International Chemical Safety Cards

COPPER

ICSC: 0240

PHYSICAL STATE; APPEARANCE:
RED POWDER, TURNS GREEN ON EXPOSURE TO MOIST AIR.

PHYSICAL DANGERS:

CHEMICAL DANGERS:
Shock-sensitive compounds are formed with acetylenic compounds, ethylene oxides and azides. Reacts with strong oxidants like chlorates, bromates and iodates, causing explosion hazard.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: ppm; 0.2 mg/m^3 fume (ACGIH 1992-1993).
TLV (as Cu, dusts & mists): ppm; 1 mg/m^3 (ACGIH 1992-1993).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation and by ingestion.

INHALATION RISK:
Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly when dispersed.

EFFECTS OF SHORT-TERM EXPOSURE:
Inhalation of fume may cause metal fever (see Notes).

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
Repeated or prolonged contact may cause skin sensitization.

Boiling point: 2595°C
Melting point: 1083°C

Relative density (water = 1): 8.9
Solubility in water: none

NOTES

The symptoms of metal fume fever do not become manifest until several hours.

ADDITIONAL INFORMATION

ICSC: 0240 **COPPER**

International Chemical Safety Cards

ARSENIC

ICSC: 0013

ARSENIC
Grey arsenic
Metallic arsenic
As
Atomic mass: 74.9

CAS # 7440-38-2
RTECS # CG0525000
ICSC # 0013
UN # 1558
EC # 033-001-00-X

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Combustible. Gives off irritating or toxic fumes (or gases) in a fire.	NO open flames. NO contact with strong oxidizers. NO contact with hot surfaces.	Powder, water spray, foam, carbon dioxide.
EXPLOSION	Risk of fire and explosion is slight if in the form of fine powder or dust when exposed to hot surfaces or flames.	Prevent deposition of dust; closed system, dust explosion-proof electrical equipment and lighting.	
EXPOSURE		AVOID ALL CONTACT!	IN ALL CASES CONSULT A DOCTOR!
INHALATION	Cough. Diarrhoea. Shortness of breath. Sore throat. Vomiting. Weakness. Grey skin.	Closed system and ventilation.	Fresh air, rest. Artificial respiration if indicated. Refer for medical attention.
SKIN	Redness.	Protective gloves. Protective clothing.	Remove contaminated clothes. Rinse skin with plenty of water or shower.
EYES	Redness.	or eye protection in combination with breathing protection if powder.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Diarrhoea. Nausea. Sore throat. Unconsciousness. Vomiting (further see Inhalation).	Do not eat, drink, or smoke during work. Wash hands before eating.	Rinse mouth. Induce vomiting (ONLY IN CONSCIOUS PERSONS!). Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Evacuate danger area! Sweep spilled substance into sealable containers. Carefully collect remainder, then remove to safe place. Do NOT let this chemical enter the environment (extra personal protection: complete protective clothing including self-contained breathing apparatus).	Provision to contain effluent from fire extinguishing. Separated from strong oxidants, acids, halogens, food and feedstuffs. Well closed. Keep in a well-ventilated room.	Do not transport with food and feedstuffs. T symbol R: 23/25 S: (1/2-)20/21-28-45 UN Hazard Class: 6.1 UN Packing Group: II Marine pollutant.

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0013

International Chemical Safety Cards

ARSENIC

ICSC: 0013

PHYSICAL STATE; APPEARANCE:
ODOURLESS, BRITTLE, GREY, METALLIC-LOOKING CRYSTALS.

PHYSICAL DANGERS:

CHEMICAL DANGERS:
Upon heating, toxic fumes are formed. Reacts violently with strong oxidants and halogens causing fire and explosion hazard. Reacts with nitric acid, hot sulfuric acid. Toxic arsine gas may be formed in contact with acid or acidic substances and certain metals, such as galvanized or light metals.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: ppm; 0.01 mg/m^3 (as TWA) A1 (ACGIH 1994-1995).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation of its aerosol, through the skin and by ingestion.

INHALATION RISK:
Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the eyes, the skin and the respiratory tract. The substance may cause effects on the circulatory system, nervous system, kidneys and gastrointestinal tract , resulting in convulsions, kidney impairment, severe hemorrhage, losses of fluids, and electrolytes, shock and death. Exposure may result in death. The effects may be delayed. Medical observation is indicated.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
Repeated or prolonged contact with skin may cause dermatitis. Repeated or prolonged contact may cause skin sensitization. The substance may have effects on the mucous membranes, skin, kidneys, liver , resulting in neuropathy, pigmentation disorders, perforation of nasal septum and tissue lesions. This substance is carcinogenic to humans.

Sublimation point: 613°C
Relative density (water = 1): 5.7

Solubility in water: none

The substance is toxic to aquatic organisms. It is strongly advised not to let the chemical enter into the environment because it persists in the environment.

NOTES

The substance is combustible but no flash point is available in literature. Depending on the degree of exposure, periodic medical examination is indicated. Do NOT take working clothes home. Refer also to cards for specific arsenic compounds,

medical examination is indicated. Do NOT take working clothes home. Refer also to cards for specific arsenic compounds, e.g., Arsenic pentoxide (ICSC # 0377), Arsenic trichloride (ICSC # 0221), Arsenic trioxide (ICSC # 0378), Arsine (ICSC # 0222).

ADDITIONAL INFORMATION	

ICSC: 0013 **ARSENIC**

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International Chemical Safety Cards

VINYL CHLORIDE

ICSC: 0082

VINYL CHLORIDE
Chloroethene
Chloroethylene
VCM
(cylinder)
$C_2H_3Cl/H_2C=CHCl$
Molecular mass: 62.5

CAS # 75-01-4
RTECS # KU9625000
ICSC # 0082
UN # 1086 (inhibited)
EC # 602-023-00-7

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Extremely flammable. Gives off irritating or toxic fumes (or gases) in a fire.	NO open flames, NO sparks, and NO smoking.	Shut off supply; if not possible and no risk to surroundings, let the fire burn itself out; in other cases extinguish with powder, carbon dioxide.
EXPLOSION	Gas/air mixtures are explosive. Vinyl chloride monomer vapours are uninhibited and may form polymers in vents or flame arresters of storage tanks, resulting in blockage of vents.	Closed system, ventilation, explosion-proof electrical equipment and lighting. Use non-sparking handtools.	In case of fire: keep cylinder cool by spraying with water. Combat fire from a sheltered position.
EXPOSURE		AVOID ALL CONTACT!	
INHALATION	Dizziness. Drowsiness. Headache. Unconsciousness.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Refer for medical attention.
SKIN	ON CONTACT WITH LIQUID: FROSTBITE.	Protective gloves. Cold-insulating gloves. Protective clothing.	ON FROSTBITE: rinse with plenty of water, do NOT remove clothes.
EYES	Redness. Pain.	Safety goggles, or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION		Do not eat, drink, or smoke during work. Wash hands before eating.	

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Evacuate danger area! Consult an expert! Ventilation (extra personal protection: complete protective clothing including self-contained breathing apparatus).	Fireproof. Separated from incompatible materials (see Chemical Danger). Cool.	F symbol T symbol R: 45-13 S: 53-9-16-44 Note: D UN Hazard Class: 2.1

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0082

International Chemical Safety Cards

VINYL CHLORIDE

ICSC: 0082

PHYSICAL STATE; APPEARANCE:
COLOURLESS COMPRESSED LIQUEFIED GAS, WITH CHARACTERISTIC ODOUR.

PHYSICAL DANGERS:
The gas is heavier than air, and may travel along the ground; distant ignition possible.

CHEMICAL DANGERS:
The substance can under specific circumstances form peroxides, initiating explosive polymerization. The substance will polymerize readily due to heating and under the influence of air, light, and on contact with a catalyst, strong oxidizing agents and metals such as copper and aluminium, with fire or explosion hazard. The substance decomposes on burning producing toxic and corrosive fumes (hydrogen chloride and phosgene).

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: 5 ppm; 13 mg/m^3 (ACGIH 1993-1994).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation.

INHALATION RISK:
A harmful concentration of this gas in the air will be reached very quickly on loss of containment.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the eyes. The liquid may cause frostbite. The substance may cause effects on the central nervous system. Exposure could cause lowering of consciousness. Medical observation is indicated.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
The substance may have effects on the liver, blood vessels and connective tissue. This substance is carcinogenic to humans. May cause heritable genetic damage in humans.

Boiling point: -13°C
Melting point: -154°C
Relative density (water = 1): 0.9
Solubility in water: none
Relative vapour density (air = 1): 2.2

Flash point: -78°C c.c.°C
Auto-ignition temperature: 472°C
Explosive limits, vol% in air: 3.6-33
Octanol/water partition coefficient as log Pow: 0.6

NOTES

According to ACGIH this substance belongs to Group A1 indicating confirmed human carcinogen. Contains inhibitors (e.g. phenol). Depending on the degree of exposure, periodic medical examination is indicated. The odour warning when the exposure limit value is exceeded is insufficient. Do NOT use in the vicinity of a fire or a hot surface, or during welding.

Transport Emergency Card: TEC (R)-150
NFPA Code: H 2; F 4; R 2;

NFPA Code: H 2; F 4; R 2;

ADDITIONAL INFORMATION	

ICSC: 0082 **VINYL CHLORIDE**

IMPORTANT LEGAL NOTICE:	Neither the CEC or the IPCS nor any person acting on behalf of the CEC or the IPCS is responsible for the use which might be made of this information. This card contains the collective views of the IPCS Peer Review Committee and may not reflect in all cases all the detailed requirements included in national legislation on the subject. The user should verify compliance of the cards with the relevant legislation in the country of use.

International Chemical Safety Cards

CHLOROBENZENE

ICSC: 0642

CHLOROBENZENE
Benzene chloride
Chlorobenzol
MCB
Phenyl chloride
C_6H_5Cl
Molecular mass: 112.6

CAS # 108-90-7
RTECS # CZ0175000
ICSC # 0642
UN # 1134
EC # 602-033-00-1

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Flammable. Gives off irritating or toxic fumes (or gases) in a fire.	NO open flames, NO sparks, and NO smoking.	Powder, water spray, foam, carbon dioxide.
EXPLOSION	Above 27°C explosive vapour/air mixtures may be formed.	Above 27°C use a closed system, ventilation, and explosion-proof electrical equipment.	In case of fire: keep drums, etc., cool by spraying with water.
EXPOSURE		PREVENT GENERATION OF MISTS! STRICT HYGIENE!	IN ALL CASES CONSULT A DOCTOR!
INHALATION	Drowsiness. Headache. Nausea. Unconsciousness.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Half-upright position. Artificial respiration if indicated. Refer for medical attention.
SKIN	Redness. Roughness.	Protective gloves.	First rinse with plenty of water, then remove contaminated clothes and rinse again. Refer for medical attention.
EYES	Redness.	Safety goggles, or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Abdominal pain. (See Inhalation).	Do not eat, drink, or smoke during work.	Rinse mouth. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent and remove to safe place. Do NOT let this chemical enter the environment (extra personal protection: filter respirator for organic gases and vapours).	Fireproof. Separated from strong oxidants. Cool.	Xn symbol N symbol R: 10-20-51/53 S: (2-)24/25-61 UN Hazard Class: 3 UN Packing Group: III

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0642

International Chemical Safety Cards

CHLOROBENZENE

ICSC: 0642

PHYSICAL STATE; APPEARANCE:
COLOURLESS LIQUID , WITH CHARACTERISTIC ODOUR.

PHYSICAL DANGERS:
The vapour is heavier than air and may travel along the ground; distant ignition possible.

CHEMICAL DANGERS:
The substance decomposes on heating, on burning and on contact with hot surfaces, producing corrosive and toxic fumes including phosgene, hydrogen chloride. Reacts violently with strong oxidants, dimethyl sulfoxide causing fire and explosion hazard. Attacks rubber and some plastics.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: 10 ppm; 46 mg/m^3 (as TWA) (ACGIH 1996).
MAK: 10 ppm; 50 mg/m^3; (1995).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation of its vapour and by ingestion.

INHALATION RISK:
A harmful contamination of the air can be reached rather quickly on evaporation of this substance at 20°C.

EFFECTS OF SHORT-TERM EXPOSURE:
Swallowing the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis. Exposure may result in unconsciousness. The effects may be delayed. Medical observation is indicated.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
The substance may have effects on the central nervous system, blood, liver, and kidneys.

PHYSICAL PROPERTIES

Boiling point: 132°C
Melting point: -45°C
Relative density (water = 1): 1.11
Solubility in water, g/100 ml at 25°C: 0.02
Vapour pressure, kPa at 20°C: 1.17
Relative vapour density (air = 1): 3.88
Flash point: 27°C c.c.
Auto-ignition temperature: 590°C
Explosive limits, vol% in air: 1.3-11
Octanol/water partition coefficient as log Pow: 2.18-2.84

ENVIRONMENTAL DATA

It is strongly advised not to let the chemical enter into the environment.

NOTES

The odour warning when the exposure limit value is exceeded is insufficient. Do NOT use in the vicinity of a fire or a hot surface, or during welding.

Transport Emergency Card: TEC (R)-90
NFPA Code: H2; F3; R0;

ADDITIONAL INFORMATION

ICSC: 0642 **CHLOROBENZENE**

International Chemical Safety Cards

DICHLOROMETHANE

ICSC: 0058

DICHLOROMETHANE
Methylene chloride
DCM
CH_2Cl_2
Molecular mass: 84.9

CAS # 75-09-2
RTECS # PA8050000
ICSC # 0058
UN # 1593
EC # 602-004-00-3

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Combustible under specific conditions. Gives off irritating or toxic fumes (or gases) in a fire.		In case of fire in the surroundings: all extinguishing agents allowed.
EXPLOSION	Risk of fire and explosion (see Chemical Dangers).		In case of fire: keep drums, etc., cool by spraying with water.
EXPOSURE		AVOID ALL CONTACT!	
INHALATION	Dizziness. Drowsiness. Headache. Nausea. Unconsciousness. Weakness. death.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Artificial respiration if indicated. Refer for medical attention.
SKIN	Dry skin. Redness. Burning sensation.	Protective gloves. Protective clothing.	Remove contaminated clothes. Rinse and then wash skin with water and soap.
EYES	Redness. Pain. Severe deep burns.	Safety goggles, face shield, or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Abdominal pain (further see Inhalation).	Do not eat, drink, or smoke during work. Wash hands before eating.	Rinse mouth. Do NOT induce vomiting. Give plenty of water to drink. Rest.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Ventilation. Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent and remove to safe place. Do NOT let this chemical enter the environment (extra personal protection: complete protective clothing including self-contained breathing apparatus).	Separated from metals (see Chemical Dangers), food and feedstuffs. Cool. Ventilation along the floor.	Unbreakable packaging; put breakable packaging into closed unbreakable container. Do not transport with food and feedstuffs. Xn symbol R: 40 S: 23-24/25-36/37 UN Hazard Class: 6.1 UN Packing Group: III

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0058

International Chemical Safety Cards

DICHLOROMETHANE

ICSC: 0058

PHYSICAL AND CHEMICAL DATA

PHYSICAL STATE; APPEARANCE:
COLOURLESS LIQUID, WITH CHARACTERISTIC ODOUR.

PHYSICAL DANGERS:
The vapour is heavier than air. As a result of flow, agitation, etc., electrostatic charges can be generated.

CHEMICAL DANGERS:
On contact with hot surfaces or flames this substance decomposes forming toxic and corrosive fumes. Reacts violently with metals such as aluminium, magnesium, sodium, potassium, lithium, strong bases and oxidants, causing fire and explosion hazard. Attacks some forms of plastics, rubber and coatings.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: 50 ppm; 174 mg/m^3 (ACGIH 1992-1993).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation, through the skin and by ingestion.

INHALATION RISK:
A harmful contamination of the air can be reached very quickly on evaporation of this substance at 20°C.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the eyes, the skin and the respiratory tract. Swallowing the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis. The substance may cause effects on the blood, resulting in formation of methaemoglobin. Exposure could cause lowering of consciousness. Exposure could cause formation of carboxyhaemoglobin.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the central nervous system and liver, resulting in degenerative brain disease and enlargement of the liver. This substance is possibly carcinogenic to humans.

PROPERTIES

Boiling point: 40°C
Melting point: -95.1°C
Relative density (water = 1): 1.3
Solubility in water, g/100 ml at 20°C: 1.3
Vapour pressure, kPa at 20°C: 47.4
Relative vapour density (air = 1): 2.9
Relative density of the vapour/air-mixture at 20°C (air = 1): 1.9
Auto-ignition temperature: 640°C
Explosive limits, vol% in air: 14-25%
Octanol/water partition coefficient as log Pow: 1.25

ENVIRONMENTAL DATA

This substance may be hazardous to the environment; special attention should be given to water organisms.

NOTES

NOTES

According to ACGIH this substance belongs to group A2 indicating suspected human carcinogen. Smoking has an additive effect on carbon monoxide formation in blood. Combustible vapour/air mixtures difficult to ignite, may be developed under certain conditions. Addition of small amounts of a flammable substance or an increase in the oxygen content of the air strongly enhances combustibility. Use of alcoholic beverages enhances the harmful effect. Depending on the degree of exposure, periodic medical examination is indicated. The odour warning when the exposure limit value is exceeded is insufficient. Do NOT use in the vicinity of a fire or a hot surface, or during welding.

Transport Emergency Card: TEC (R)-720
NFPA Code: H2; F1; R0;

ADDITIONAL INFORMATION

ICSC: 0058 **DICHLOROMETHANE**

International Chemical Safety Cards

p-XYLENE

ICSC: 0086

p-XYLENE
para-Xylene
1,4-Dimethylbenzene
p-Xylol
$C_6H_4(CH_3)_2/C_8H_{10}$
Molecular mass: 106.2

CAS # 106-42-3
RTECS # ZE2625000
ICSC # 0086
UN # 1307
EC # 601-022-00-9

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Flammable.	NO open flames, NO sparks, and NO smoking.	Powder, AFFF, foam, carbon dioxide.
EXPLOSION	Above 27°C explosive vapour/air mixtures may be formed.	Above 27°C use a closed system, ventilation, and explosion-proof electrical equipment.	In case of fire: keep drums, etc., cool by spraying with water.
EXPOSURE		STRICT HYGIENE! AVOID EXPOSURE OF (PREGNANT) WOMEN!	
INHALATION	Dizziness. Drowsiness. Headache. Unconsciousness.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Artificial respiration if indicated. Refer for medical attention.
SKIN	Dry skin. Redness.	Protective gloves.	Remove contaminated clothes. Rinse and then wash skin with water and soap.
EYES	Redness. Pain.	Safety spectacles.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Abdominal pain. Burning sensation (further see Inhalation).	Do not eat, drink, or smoke during work.	Rinse mouth. Give a slurry of activated charcoal in water to drink. Do NOT induce vomiting. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent and remove to safe place. Do NOT let this chemical enter the environment.	Fireproof. Separated from strong oxidants.	Xn symbol R: 10-20/21-38 S: (2-)25 UN Hazard Class: 3

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0086

International Chemical Safety Cards

p-XYLENE

ICSC: 0086

PHYSICAL STATE; APPEARANCE:
COLOURLESS LIQUID , WITH CHARACTERISTIC ODOUR.

PHYSICAL DANGERS:
As a result of flow, agitation, etc., electrostatic charges can be generated.

CHEMICAL DANGERS:
Reacts violently with strong oxidants such as nitric acid.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: 100 ppm; 434 mg/m^3 (as TWA) (ACGIH 1993-1994).
TLV (as STEL): 150 ppm; 651 mg/m^3 (ACGIH 1993-1994).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation, through the skin and by ingestion.

INHALATION RISK:
A harmful contamination of the air will be reached rather slowly on evaporation of this substance at 20°C.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the eyes. Exposure far above the OEL may result in central nervous system depression, unconsciousness and death.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
The liquid defats the skin. The substance may have effects on the central nervous system, resulting in decreased learning ability. Animal tests show that this substance possibly causes toxic effects upon human reproduction.

PHYSICAL PROPERTIES

Boiling point: 138°C
Melting point: 13°C
Relative density (water = 1): 0.86
Solubility in water: none
Vapour pressure, kPa at 20°C: 0.9
Relative vapour density (air = 1): 3.7
Relative density of the vapour/air-mixture at 20°C (air = 1): 1.02
Flash point: 27°C c.c.°C
Auto-ignition temperature: 528°C
Explosive limits, vol% in air: 1.1-7.0
Octanol/water partition coefficient as log Pow: 3.15

ENVIRONMENTAL DATA

This substance may be hazardous to the environment; special attention should be given to fish and crustacea.

NOTES

Depending on the degree of exposure, periodic medical examination is indicated. The recommendations on this Card also

Depending on the degree of exposure, periodic medical examination is indicated. The recommendations on this Card also apply to technical xylene. Also consult ICSC # 0084 o-xylene and 0085 m-xylene.

Transport Emergency Card: TEC (R)-33
NFPA Code: H 2; F 3; R 0;

ADDITIONAL INFORMATION

ICSC: 0086 **p-XYLENE**

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International Chemical Safety Cards

VINYLIDENE CHLORIDE

ICSC: 0083

VINYLIDENE CHLORIDE
1,1-Dichloroethene
1,1-Dichloroethylene
VDC
$C_2H_2Cl_2/H_2C=CCl_2$
Molecular mass: 97

CAS # 75-35-4
RTECS # KV9275000
ICSC # 0083
UN # 1303 (inhibited)
EC # 602-025-00-8

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Extremely flammable. Gives off irritating or toxic fumes (or gases) in a fire.	NO open flames, NO sparks, and NO smoking.	Powder, water spray, foam, carbon dioxide.
EXPLOSION	Vapour/air mixtures are explosive. Vinyl chloride monomer vapours are uninhibited and may form polymers in vents or flame arresters of storage tanks, resulting in blockage of vents.	Closed system, ventilation, explosion-proof electrical equipment and lighting. Use non-sparking handtools.	In case of fire: keep drums, etc., cool by spraying with water. Combat fire from a sheltered position.
EXPOSURE		STRICT HYGIENE!	
INHALATION	Dizziness. Drowsiness. Unconsciousness.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Artificial respiration if indicated. Refer for medical attention.
SKIN	Redness. Skin burns.	Protective gloves. Protective clothing.	Remove contaminated clothes. Rinse and then wash skin with water and soap.
EYES	Redness. Pain.	Safety goggles, or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
INGESTION	Abdominal pain. Sore throat (further see Inhalation).	Do not eat, drink, or smoke during work. Wash hands before eating.	Rinse mouth. Do NOT induce vomiting. Give plenty of water to drink. Rest.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Evacuate danger area! Consult an expert! Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent and remove to safe place (extra personal protection: complete protective clothing including self-contained breathing apparatus).	Fireproof. Separated from incompatible materials (see Chemical Dangers). Cool. Keep in the dark. Store only if stabilized.	Airtight. Unbreakable packaging; put breakable packaging into closed unbreakable container. IMO: Marine Pollutant F+ symbol Xn symbol R: 12-20-40 S: 7-16-29 Note: D UN Hazard Class: 3 UN Packing Group: I

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0083

International Chemical Safety Cards

VINYLIDENE CHLORIDE

ICSC: 0083

PHYSICAL STATE; APPEARANCE:
VOLATILE COLOURLESS LIQUID, WITH CHARACTERISTIC ODOUR.

PHYSICAL DANGERS:
The vapour is heavier than air and may travel along the ground; distant ignition possible.

CHEMICAL DANGERS:
The substance can readily form explosive peroxides. The substance will polymerize readily due to heating or under the influence of oxygen, sunlight, copper or aluminium, with fire or explosion hazard. May explode on heating or on contact with flames. The substance decomposes on burning producing toxic and corrosive fumes (hydrogen chloride, phosgene and chlorine). Reacts violently with oxidants.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: 5 ppm; 20 mg/m^3 (STEL): 20 ppm; 79 mg/m^3 (ACGIH 1992-1993).

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation, through the skin and by ingestion.

INHALATION RISK:
A harmful contamination of the air can be reached very quickly on evaporation of this substance at 20°C.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the eyes, the skin and the respiratory tract. Swallowing the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis. The substance may cause effects on the central nervous system.

EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:
Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the liver and kidneys.

PHYSICAL PROPERTIES

Boiling point: 32°C
Melting point: -122°C
Relative density (water = 1): 1.2
Solubility in water, g/100 ml at 25°C: 0.25
Vapour pressure, kPa at 20°C: 66.5
Relative vapour density (air = 1): 3.3
Relative density of the vapour/air-mixture at 20°C (air = 1): 2.5
Flash point: 5.6°C
Auto-ignition temperature: 570°C
Explosive limits, vol% in air: 5.6-16
Octanol/water partition coefficient as log Pow: 1.32

ENVIRONMENTAL DATA

This substance may be hazardous to the environment; special attention should be given to water organisms. In the food chain important to humans, bioaccumulation takes place, specifically in plants.

NOTES

NOTES

Contains inhibitors (e.g. methoxyphenol). Depending on the degree of exposure, periodic medical examination is indicated. The odour warning when the exposure limit value is exceeded is insufficient. Do NOT use in the vicinity of a fire or a hot surface, or during welding.

Transport Emergency Card: TEC (R)-641
NFPA Code: H2; F4; R2;

ADDITIONAL INFORMATION

ICSC: 0083 **VINYLIDENE CHLORIDE**

ACCUSTANDARD -- 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN SOLUTION, M-613
MATERIAL SAFETY DATA SHEET
NSN: 685000N072525
Manufacturer's CAGE: 0U4A8
Part No. Indicator: A
Part Number/Trade Name: 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN SOLUTION, M-613

General Information

Company's Name: ACCUSTANDARD INC
Company's Street: 25 SCIENCE PARK SUITE 687
Company's City: NEW HAVEN
Company's State: CT
Company's Country: US
Company's Zip Code: 06511
Company's Emerg Ph #: 203-786-5290
Company's Info Ph #: 203-786-5290
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SMJ
Date MSDS Prepared: 24FEB95
Safety Data Review Date: 29AUG96
MSDS Serial Number: CBYLC

Ingredients/Identity Information

Proprietary: NO
Ingredient: DIBENZO-P-DIOXIN, 2,3,7,8-TETRACHLORO-; (2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN) (TCDD) (CERCLA)
Ingredient Sequence Number: 01
Percent: 0.001
NIOSH (RTECS) Number: HP3500000
CAS Number: 1746-01-6
OSHA PEL: N/K (FP N)
ACGIH TLV: N/K (FP N)

Proprietary: NO
Ingredient: TOLUENE (SARA 313) (CERCLA)
Ingredient Sequence Number: 02
Percent: 99.999
NIOSH (RTECS) Number: XS5250000
CAS Number: 108-88-3
OSHA PEL: 200 PPM
ACGIH TLV: 50 PPM, S

Physical/Chemical Characteristics

Appearance And Odor: CLEAR LIQUID, WITH AROMATIC ODOR
Boiling Point: 232F,111C
Melting Point: -139F,-95C
Vapor Pressure (MM Hg/70 F): 21.9 @ 20C
Vapor Density (Air=1): 3.2
Specific Gravity: 0.87 (H*2O=1)
Evaporation Rate And Ref: 2.2 (BUTYL ACETATE=1)
Solubility In Water: INSOLUBLE
Percent Volatiles By Volume: >99

Fire and Explosion Hazard Data

Flash Point: 40.0F,4.4C
Flash Point Method: TCC
Lower Explosive Limit: 1.30%
Upper Explosive Limit: 7.10%
Extinguishing Media: USE DRY CHEMICAL, FOAM, CARBON DIOXIDE. WATER SPRAY TO COOL EXPOSED CONTAINERS.

Special Fire Fighting Proc: WEAR NIOSH APPROVED SCBA AND FULL PROTECTIVE EQUIPMENT (FP N).
Unusual Fire And Expl Hazrds: DANGEROUS FIRE AND EXPLOSION HAZARD. VAPOR CAN TRAVEL DISTANCES TO IGNITION SOURCES AND FLASH BACK.

Reactivity Data

Stability: YES
Cond To Avoid (Stability): HEAT; CONTACT WITH IGNITION SOURCES.
Materials To Avoid: OXIDIZERS, STRONG MINERAL ACIDS.
Hazardous Decomp Products: CO*X, HYDROCARBONS.
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): NOT RELEVANT.

Health Hazard Data

LD50-LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: ACUTE: HARMFUL/FATAL IF SWALLOWED. VAP HARMFUL IF INHALED. SYMPS: HDCH, DIZZ, HALLUCINATIONS, DISTORTED PERCEPTIONS, CHANGES IN MOTOR ACTIVITY, NAUS, RESP IRRIT, CNS DEPRESS, UNCON, LIVER, KIDNEY & LUNG DMG. CONT MAY CAUSE SEV EYE IRRIT. MAY CAUSE SKIN IRRIT. CHRONIC: TOLUENE APPEARS ON THE NAVY (EFTS OF OVEREXPOSURE)
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NOT RELEVANT.
Signs/Symptoms Of Overexp: HLTH HAZ: OCCUPATIONAL CHEMICAL REPRODUCTIVE HAZARDS LIST. SEEK CONSULTATION FROM APPROPRIATE HEALTH PROFESSIONALS CONCERNING LATEST HAZARD LIST INFORMATION AND SAFE HANDLING AND EXPOSURE INFORMATION (FP N).
Med Cond Aggravated By Exp: RESPIRATORY, LIVER AND KIDNEY CONDITIONS.
Emergency/First Aid Proc: GET MEDICAL ASSISTANCE FOR ALL CASES OF OVEREXPOSURE. EYES: IMMEDIATELY FLUSH THOROUGHLY W/WATER FOR AT LEAST 15 MINUTES. SKIN: IMMEDIATELY FLUSH THOROUGHLY W/LARGE AMOUNTS OF WATER. INHAL: REMOVE TO FRESH AIR; GIVE ARTIFICIAL RESPIRATION IF BREATHING HAS STOPPED. INGEST: CALL MD IMMEDIATELY. ONLY INDUCE VOMITING AT THE INSTRUCTIONS OF MD. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: WEAR SUITABLE PROTECTIVE EQUIPMENT. ELIMINATE ANY IGNITION SORUCES UNTIL THE AREA IS DETERMINED TO BE FREE FROM EXPLOSION OR FIRE HAZARDS. CONTAIN THE RELEASE AND ELIMINATE ITS SOURCE, IF THIS CAN BE DONE WITHOUT RISK.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Method: DISPOSE AS HAZARDOUS WASTE. COMPLY WITH FEDERAL, STATE AND LOCAL REGULATIONS.
Precautions-Handling/Storing: KEEP CONTAINER TIGHTLY CLOSED. STORE IN A COOL AREA AWAY FROM IGNITION SOURCES AND OXIDIZERS. DO NOT BREATHE VAPOR OR MIST.
Other Precautions: DO NOT GET IN EYES, ON SKIN, OR ON CLOTHING. ELECTRICALLY GROUND ALL EQUIPMENT WHEN HANDLING THIS PRODUCT.

Control Measures

Respiratory Protection: IF WORKPLACE EXPOS LIM OF PROD/ANY COMPONENT IS EXCEEDED (SEE TLV/PEL), A NIOSH APPRVD AIR SUPPLIED RESP IS ADVISED IN ABSENCE OF PROPER ENVIRON CTL. OSHA REGS ALSO PERMIT OTHER NIOSH APPRVD RESPS (NEG PRESS TYPE) UNDER SPECIFIED (SUP DAT)
Ventilation: MATERIAL SHOULD BE HANDLED OR TRANSFERRED IN AN APPROVED FUME HOOD OR WITH ADEQUATE VENTILATION.
Protective Gloves: VITON OR EQUIVALENT.

Eye Protection: ANSI APPRVD CHEM WORKERS GOGGS (FP N).
Other Protective Equipment: EMERGENCY EYEWASH & DELUGE SHOWER MEETING ANSI DESIGN CRITERIA (FP N).
Work Hygienic Practices: WASH THOROUGHLY AFTER HANDLING. DO NOT TAKE INTERNALLY.
Suppl. Safety & Health Data: RESP PROT: CNDTNS (SEE YOUR SFTY EQUIP SUPPLIER). ENGINEERING AND/OR ADMINISTRATIVE CONTROLS SHOULD BE IMPLEMENTED TO REDUCE EXPOS.

Transportation Data

Disposal Data

Label Data

Label Required: YES
Technical Review Date: 29AUG96
Label Date: 29AUG96
Label Status: G
Common Name: 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN SOLUTION, M-613
Chronic Hazard: YES
Signal Word: DANGER!
Acute Health Hazard-Moderate: X
Contact Hazard-Moderate: X
Fire Hazard-Severe: X
Reactivity Hazard-None: X
Special Hazard Precautions: FLAMMABLE. ACUTE: HARMFUL OR FATAL IF SWALLOWED. VAPOR HARMFUL IF INHALED. SYMPTOMS: HEADACHE, DIZZINESS, HALLUCINATIONS, DISTORTED PERCEPTIONS, CHANGES IN MOTOR ACTIVITY, NAUSEA, RESPIRATORY IRRITATION, CENTRAL NERVOUS SYSTEM DEPRESSION, UNCONSCIOUSNESS, LIVER, KIDNEY AND LUNG DAMAGE. CONTACT MAY CAUSE SEVERE EYE IRRITATION. MAY CAUSE SKIN IRRITATION. CHRONIC: TOLUENE APPEARS ON THE NAVY OCCUPATIONAL CHEMICAL REPRODUCTIVE HAZARDS LIST (FP N).
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: ACCUSTANDARD INC
Label Street: 25 SCIENCE PARK SUITE 687
Label City: NEW HAVEN
Label State: CT
Label Zip Code: 06511
Label Country: US
Label Emergency Number: 203-786-5290

Appendix C

Table 8-10 USEPA Occupational Safety & Health Guidance Manual for Hazardous Waste Site Activities

Table 8-10. Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers[a]

ADJUSTED TEMPERATURE[b]	NORMAL WORK ENSEMBLE[c]	IMPERMEABLE ENSEMBLE
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5° - 90°F (30.8° - 32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5° - 87.5°F (28.1° - 30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5° - 82.5°F (25.3° - 28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5° - 77.5°F (22.5° - 25.3°C)	After each 150 minutes of work	After each 120 minutes of work

Source: Reference [13].

[a]For work levels of 250 kilocalories/hour.

[b]Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F = ta °F + (13 × % sunshine). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)

[c]A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

Table 8-11. Signs and Symptoms of Heat Stress[a]

- **Heat rash** may result from continuous exposure to heat or humid air.
- **Heat cramps** are caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include:
  - muscle spasms
  - pain in the hands, feet, and abdomen
- **Heat exhaustion** occurs from increased stress on various body organs including inadequate blood circulation due to cardiovascular insufficiency or dehydration. Signs and symptoms include:
  - pale, cool, moist skin
  - heavy sweating
  - dizziness
  - nausea
  - fainting
- **Heat stroke** is the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before serious injury and death occur. Competent medical help must be obtained. Signs and symptoms are:
  - red, hot, usually dry skin
    lack of or reduced perspiration
  - nausea
  - dizziness and confusion
  - strong, rapid pulse
  - coma

[a]Source: Reference [6].

responses, and some of the precautionary and training measures that need to be taken to avoid PPE-induced injury.

The physiological factors may affect worker ability to function using PPE include:

- Physical condition.
- Level of acclimatization.
- Age.
- Gender.
- Weight.

Physical Condition

Physical fitness is a major factor influencing a person's ability to perform work under heat stress. The more fit someone is, the more work they can safely perform. At a given level of work, a fit person, relative to an unfit person, will have [5,8,15,16]:

- Less physiological strain.
- A lower heart rate.
- A lower body temperature, which indicates less retained body heat (a rise in internal temperature precipitates heat injury).
- A more efficient sweating mechanism.
- Slightly lower oxygen consumption.
- Slightly lower carbon dioxide production.

Level of Acclimatization

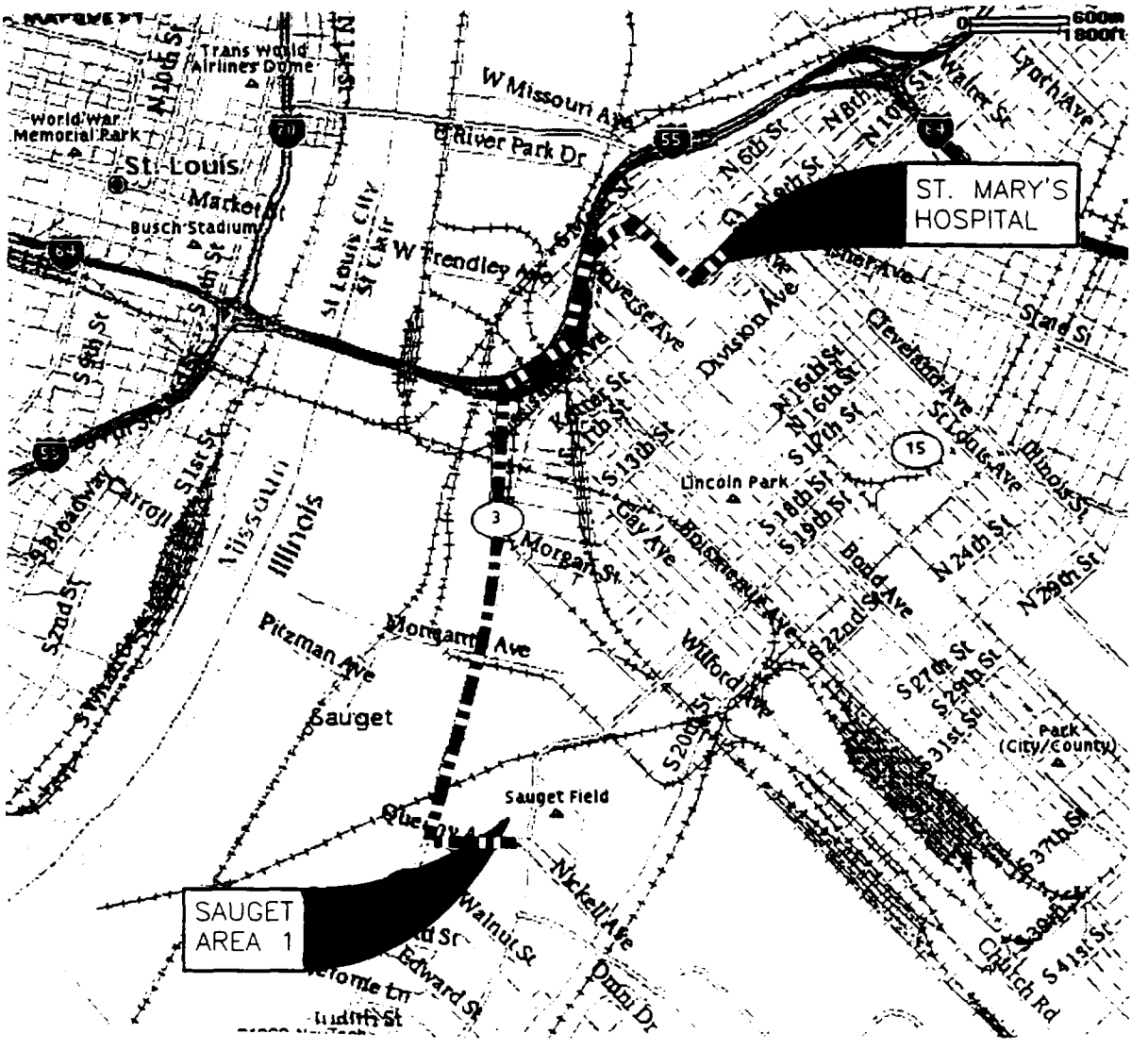
The degree to which a worker's body has physiologically adjusted or acclimatized to working under hot conditions affects his or her ability to do work. Acclimatized individuals generally have lower heart rates and body temperatures than unacclimatized individuals [17], and sweat sooner and more profusely. This enables them to maintain lower skin and body temperatures at a given level of environmental heat and work loads than unacclimatized workers [18]. Sweat composition also becomes more dilute with acclimatization, which reduces salt loss [8].

EXHIBITS

Exhibit A

Directions to hospital nearest site

FIGURE 1



SOLUTIA INC. SAUGET AREA 1
SAUGET AREA 1 SUPPORT SAMPLING

DIRECTIONS TO HOSPITAL NEAREST SITE

23548.010.01
3/11/99

O'BRIEN & GERE ENGINEERS INC.